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THE SEGMENTATION OF THE ABDOMEN OF THE HONEYBEE (Apis mellifica L.).

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The determination of the number of segments represented in the insect body has proved sufficiently interesting to attract the attention of a considerable number of morphologists. In this field the segmentation of the head has been the more perplexing part of the problem as well as the more difficult, in contrast with the segmentation of the trunk. The latter, however, has the advantage of being capable of a reasonably certain solution. The earlier workers in this field regarded the trunk of the insect as consisting of ten, or in some cases, of eleven segments. The tenth or eleventh segment, recognized as in most respects comparable to those anterior to it, was regarded as constituting the terminal or end segment, bearing the anal opening. For instance, in *Hylotoma* the eleventh segment bears appendages and possesses a neuromere (Graber 1890) and in *Xiphidium* this segment also bears a pair of appendages, the cerci (Wheeler 1893). Heymons (1895, 1895a), paid especial attention to this problem and introduced the conception, now generally accepted, of a terminal segment or telson—stated to be especially evident in *Gryllotalpa*—comparable to the telson of the *Crustacea*, containing the anus but differing from the other segments in not having paired appendages or other strictly metameric organs. In addition to the appendages of the eleventh segment Heymons found in *Phyllodromia* well defined cœlomic sacs in this segment. In later papers (1896, 1897), Heymons has elaborated this conception, finding plain

evidence of twelve segments in representatives of the *Odonata*, and *Ephemeridæ*, and also in *Lepisma* and other representatives of the *Apterygota*.

This subject has since received but little attention. Carriere and Bürger (1897) state that the abdomen of embryos of the mason bee is composed of ten segments and a telson (p. 330). Further on it is said that eleven pairs of ganglia are present in the abdomen of embryos (p. 368). The latter statement is probably from the pen of Bürger, and clearly indicates the presence of eleven true segments in addition to the telson. This is also seen in the figures. Hirschler (1909) reports finding in *Donacia* "20 Körpersegmente (eventuell 21, wenn wir aus theoretischen Grunden das 12 Abdominalsegment zurechnen)." His figures—especially figures 62 and 64—show clearly eleven abdominal segments in addition to the hypothetical telson.

In the honeybee Bütschli (1870), in one of the earliest accounts of the embryology of this insect, expressly states that there are 17 pairs of ganglia in the ventral chain, and clearly shows three ganglionic swellings in the terminal ganglion in his figure 40. This observation has apparently been overlooked by all subsequent writers on this subject. For example, Grassi (1884), the next investigator after Bütschli to study the embryology of the honeybee, states that the ganglionic chain in the trunk consists of only 13 ganglia.

The writer (1915) reported finding eleven segments bearing neuromeres in the abdomen of embryos of the honeybee and gave figures of the posterior end of embryos showing the development of this part of the ventral chain. Ten pairs of ganglia and the rudiments of the eleventh pair are formed in the abdomen, the 9th, 10th and rudimentary 11th pairs uniting to form a compound ganglion. The evidence was in this instance rather briefly presented and in fact on review appeared rather unsatisfactory. For this reason it appeared to be desirable to present the evidence in a more complete form and also to add some observations regarding the conditions obtaining in larvæ.

At about the stage designated X by the writer (1915), when the rudiments of the antennæ and gnathal appendages are well formed and the development of the organ systems is well under way, sagittal sections, either optical or actual, clearly show that the abdomen is divided into eleven segments, in each of which is a neuromere, representing a pair of ganglia. A few hours

later, at Stage XII, the ventral nerve cord becomes split off from the hypodermis. The 9th, 10th and 11th abdominal segments are now very distinct (text Fig. 1A) and are also shorter than the rest. In these segments the ganglia are still in intimate contact with the hypodermis. Shortly afterwards the separation of the nerve cord is completed and the three pairs of

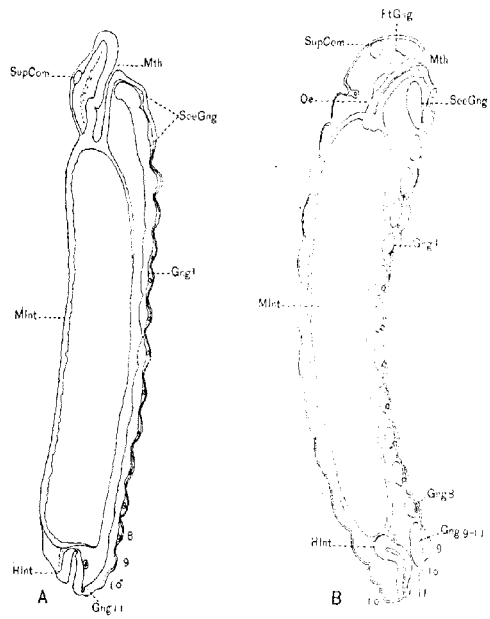


Fig. 1. *A*—Sagittal section through an embryo of Stage XIII. *B*—Sagittal section through recently hatched larva. Nervous system stippled, other organs shown in outline only. *FtGng*, frontal ganglion; *Gng 1–11*, abdominal ganglia 1–11; *HInt*, hind-intestine; *MInt*, mid-intestine; *Mth*, mouth; *Oe*, oesoph-agus; *SoeGng*, suboesophageal ganglion; *SupCom*, supraoesophageal commissure. Abdominal segments indicated by numerals. From camera drawings.

ganglia belonging to these segments appear as a compound ganglion consisting of two evident pairs of simple ganglia equipped with double transverse commissures (indicated in the figures by a lighter shade) and the rudiment of a third pair (Pl. p. 6, Fig. 1). The limits between abdominal segments 9, 10 and 11 are still well defined. Shortly afterward, when the larva has emerged from the egg, the boundaries between the 10th

and 11th abdominal segments can no longer be determined with certainty (text Fig. 1B and Fig. 2). The terminal compound ganglion (*Gng 9-11*) has become shorter and thicker and now lies almost entirely in the 9th abdominal segment. This displacement is due to a lengthening of the trunk and not to an actual shortening of the nerve chain.

The formation of a ganglion—or pair of ganglia—in the 11th abdominal segment also occurs in *Lepisma* (Heymons 1897), *Gryllotalpa, Periplaneta, Gryllus* (Heymons 1895), *Odonata* and *Ephemerida* (Heymons 1896), *Leptinotarsa* (Doryphora) (Wheeler 1889), *Donacia* (Hirschler 1909), *Hylotoma* (Graber 1890) and *Chalicodoma* (Carriere and Bürger 1898). The fusion of the terminal ganglia of the ventral cord to form a compound ganglion is apparently general among insects. The number of ganglia thus united varies, but appears in young larvæ to be usually three or four, more frequently the latter number. Of the forms above listed, the Ephemerida, as well as embryos of *Hylotoma* and *Chalicodoma* agree with the young honeybee larva in having a terminal ganglion made up of three ganglia. In all cases in which a ganglion rudiment is formed in the 11th abdominal segment this rudiment is distinctly smaller than the others and very usually forms only a vestigial, or at least much reduced ganglion, as in the honeybee. Hirschler (1909) makes the suggestion that in those species of Coleoptera, such as *Hydrophilus*, in which the ganglion of the 11th abdominal segment has not been observed, this ganglion rudiment has suffered reduction to the point of disappearing altogether. This assumption may of course be extended to other insects than those of the order Coleoptera, such as *Forficula*, in which Heymons (1895) could find no neuromere in the 11th abdominal segment.

At the time of hatching, the dorsal hypodermis shows no evidence of an eleventh abdominal segment, only ten of these being indicated by constrictions (text Fig. 1B). Since the formation of the dorsal hypodermis is completed only shortly prior to hatching, it seems reasonable to conclude that only the sternal part of the eleventh abdominal segment is present. This, as is sufficiently evident, unites with the sternal part of the 10th segment. A similar condition obtains according to Heymons (1896) in the true Orthoptera, the *Plecoptera* and some *Odonata* (imagines), the tergum of the 11th abdominal segment being absent in these forms.

The presence of a telson or anal segment in insects seems to be well established on the evidence afforded by the Odonata and Ephemerida, as well as on theoretical grounds (Heymons 1896). The abdomen of the honeybee may therefore be considered as consisting of 12 segments. There is, however, in the honeybee embryo some direct evidence indicating the presence

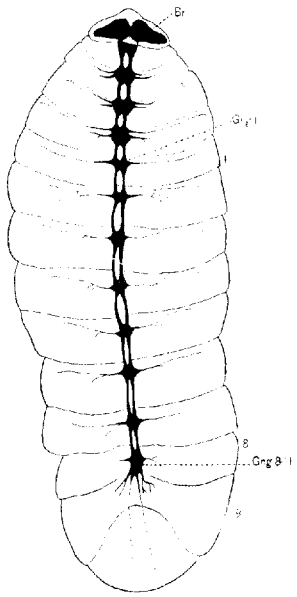
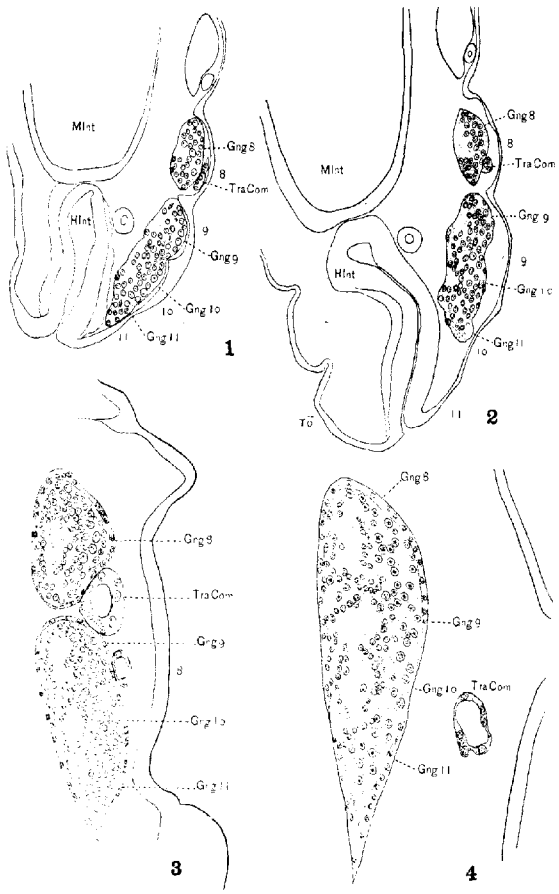


Fig. 2. Nervous system of mature larva. *Br*, brain; *Grg I–II*, abdominal ganglia I–II. Abdominal segments indicated by numerals. From camera drawing of a dissection.

of an anal segment. At Stage XII (text Fig. 1A) the ventral hypodermis just cephalad of the proctodæum is indented internally by a deep notch or transverse groove, internally by a shallower one, directly opposite to one another and reducing the intervening hypodermis to one layer of cells. These notches may readily be interpreted as corresponding to intersegmental constrictions and therefore as marking the limits between the 11th abdominal and anal segments. Vestiges of this separation are also to be seen in later stages, but disappear by the time embryonic development is completed.



EXPLANATION OF PLATE.

Fig. 1. Sagittal section through the posterior end of an embryo of Stage XII. × 260.

Fig. 2. Sagittal section through the posterior end of a recently hatched larva. × 260.

Fig. 3. Sagittal section through the 8th abdominal and terminal ganglia of a larva three days old. × 260.

Fig. 4. Sagittal section through the terminal ganglion of a mature larva. × 260.

Abbreviations: *Gng 8-11*—abdominal ganglia 8-11; *H Int*—hind-intestine; *M Int*—mid-intestine; *TraCom*—tracheal commissure of the 8th abdomnal segment. Abdominal segments indicated by numerals.

As already stated, the ventral nerve cord of the young bee larva consists, in addition to the suboesophageal ganglion, of eleven single (paired) ganglia, and a terminal ganglion composed of three ganglia, the third being much reduced. In mature or nearly mature larvæ (4–5 days old) the ventral nerve chain contains only ten single ganglia and one elongate terminal ganglion situated in the 8th abdominal segment instead of the 9th, as in young larvæ (text Fig. 2). Longitudinal sections through this ganglion show that it is made up of four ganglia, the 8th, 9th and 10th and rudimentary 11th abdominal ganglia (Fig. 4). This ganglion has now a very compact structure, the transverse commissures of the 9th and 10th abdominal segments being brought close together. Sections through younger larvæ of different ages show that the incorporation of the 8th abdominal ganglion into the compound terminal ganglion takes place slowly, being preceded by a gradual approximation of the 8th and the terminal ganglia extending over almost the entire larval period. As the larva increases in size the 8th and 9th (terminal) abdominal ganglia move up into the 8th abdominal segment, as shown in Figure 3, which represents a section through the last two ganglia of a larva three days old. This cephalad migration indicates a relative shortening of the entire ventral nerve cord, probably caused by the evident failure of the nervous system to keep pace with the rest of the larva in respect to increase in size. The terminal ganglion of an old larva possesses four pairs of lateral nerves, the first two having a common root, innervating the 8th abdominal segment while the other two pairs innervate the 9th and 10th abdominal segments and are referable to the ganglia originating in these segments.

The fusion of the four last ganglia of the ventral nerve cord in the larva evidently foreshadows the imaginal condition, although there is no further union of ganglia during the larval period. The composition of the ventral cord in the young larva, the mature larva and the imago may be expressed in the following formulæ, the ganglia of the thoracic segments being indicated by Roman, the abdominal by Arabic numerals, and the ganglia united together to form compound ganglia being enclosed by brackets:

Newly hatched larva..I, II, III, 1, 2, 3, 4, 5, 6, 7, 8, [9, 10, 11].
Mature larva.....I, II, III, 1, 2, 3, 4, 5, 6, 7, [8, 9, 10, 11].
Imago (Snodgrass 1910).I, [II, III, 1, 2], 3, 4, 5, [6, 7], [8, 9, 10, 11].

SUMMARY.

1. The embryos of the honeybee afford plain evidence of the presence of 12 segments in the abdomen, (assuming the presence of a telson), the 11th abdominal segment being represented by its sternite and by the rudiment of a pair of ganglia.

2. In newly hatched larvæ the last three abdominal ganglia, including the rudimentary 11th abdominal, unite to form a compound ganglion situated in the 9th abdominal segment. As the larva grows older the compound terminal ganglion and the ganglion of the 8th abdominal segment move closer together and both come to lie in this segment. In mature larvæ (4–5 days old) the ganglion of the 8th abdominal segment finally becomes incorporated in the terminal compound ganglion, which has then the same composition, as regards number of ganglia, as the terminal ganglion in the imaginal ventral nerve cord.

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OBSERVATIONS ON THE LIFE HISTORY AND BIOLOGY OF AGROMYZA LATERELLA ZETTERSTEDT. (Diptera).*

P. W. CLAASSEN.

In the spring of 1916, while studying the interrelation of insects to certain swamp plants near Ithaca, New York, my attention was called to the occurrence of galls on the common wild blue flag, *Iris versicolor*. The plants then were from six to ten inches high, with three or four leaves out. The galls were always found on the outer leaf of the leaf-bundle, the

FIGURE 1

affected leaf ceasing to grow. This formation of the gall and the subsequent cessation of growth of the leaf very often affects the second or next inner leaf in a peculiar manner; the tip remains caught in the gall for some time, the growing leaf is bent out and in its rapid growth produces a number of wavy or undulating folds. Fig. 1 shows a photograph of a small group of plants with several galls and the characteristic appearance of the second leaf.

*Contribution from the Entomological Laboratory of Cornell University.

On cutting the gall open a small dipterous puparium was found inside. These puparia were taken to the laboratory, placed in vials, and on the 26th of May adult flies began to emerge. These were identified by Dr. O. A. Johannsen as *Agromyza laterella*.

In going over the literature on this species, I find that Thompson† reports having bred *A. laterella* (equals *magnicornis* Loew) from galls on blue flag. His paper is accompanied with an illustration of an iris leaf showing the gall. A short description of the gall is given. He suggests that the larval life seems to be completed the previous fall, but has not investigated this assumption.

With the adults emerging the latter part of May, the question naturally arose as to where the eggs would be placed, or in what stage the summer and fall would be spent, assuming that the winter was passed in the pupal stage. With this object in view a number of the adults were placed in cages with iris plants, in an effort to induce the flies to mate and oviposit; they failed, however, to reward the observer with either of these performances in captivity. It was found, though, that the adults were very common around iris plants, especially during the middle part of the day. At such times the females were carefully observed. They appear very nervous, darting here and there, and are easily disturbed. It was noticed that the females were stopping often to exert their ovipositors and work them on the tissue of the leaf. Such a leaf, later, showed a speckled appearance as shown in Plate II, Fig. 11. A number of these leaves were taken into the laboratory and an effort made to locate the eggs, but although these punctures or abrasions were very apparent, the eggs were not found.

It was while observing this "oviposition," that Dr. Needham suggested the possibility of having a case here, where the first generation of flies took on the leaf-mining habit, while the later, or second generation would be the ones producing the galls. Should this alternation of habits occur in the same species of insect, it would help to substantiate the theory that leaf-mining and gall-making are very closely related, the main

†Millet B. Thompson, Psyche Vol. XIV, 71-74, 1913. "Three galls made by Cyclorrhaphous Flies."

difference lying in the time of attack. The stimulus for the formation of the gall being given while the plant is young and the tissues are still forming; on the other hand, oviposition and the entrance of the larva into the leaf later, when the leaf has reached its main growth, does not stimulate the tissues to form any swelling whatsoever, the result being a mine.

Although no eggs were found, the plants were carefully watched for mines. On June 22, 1916, very delicate mines were found on the innermost leaves of the leaf-bundle. These mines are first noticeable on the outer surface, under the very thin epidermis of the leaf. The larvæ remain very close to the outer skin. The mines at first are so delicate as to be hardly perceptible to the naked eye, but with the aid of a magnifying glass, could be traced to the so-called egg-punctures, but no signs of the eggs were found.

In form the mine is linear, enlarging slightly as the larva proceeds downward and increases in size. The mine zigzags quite a little in its course, frequently the larva suddenly changes to the opposite side of the leaf, so that the mine is no longer visible on the upper surface, thus presenting a broken appearance. (Plate I, Fig. 1).

The color of the mine is white and shows plainly on the green leaf, but shows more plainly on the lower part of the leaf, which in the iris is of a purplish color.

The larva proceeds downward just about as rapidly as the new leaves are formed and come out of the leaf-bundle, and passes on, thus being in a situation where the tissue is newest and most tender. Sometimes, however, the larvæ may remain in the outer leaves and mine the entire length of it. This is especially true of the early larvæ. Plate I, Fig. 1 shows one of these outer leaves with the characteristic mines in it. It is not uncommon to find two or three larvæ working side by side in the same leaf, although each one maintains its own mine. The larvæ always maintain a lateral position in the mine, that is with the sides of the body toward the two surfaces of the leaf, always mining towards the base of the leaf; but just before pupation the larva assumes a position with the dorso-ventral sides towards the surfaces of the leaf, and with the anterior end upwards.

Puparia of these larvæ were first observed on July 25, 1916. In cases where larvæ reached maturity in the early or mid-summer, the puparia were always found at the base of one of the large outer leaves. Here the larva mines more to the center of the leaf-base, so that the mine is well within the tissue of the leaf and not visible from the outside. A somewhat enlarged excavation is made here, the larva assumes its position for pupation, and transformation occurs. The base of the leaf around the puparium swells just a little, thus showing a slight tendency toward gall-formation, (Plate II, Fig. 7).

Later in the fall the leaf is often found split open at the base, thus exposing the puparium. These puparia remain in this condition till the following spring.

Owing to the fact that oviposition stretches over a considerable length of time, (adults were seen around the iris plants for three or four weeks) different stages of larvæ were found in the iris all summer.

The larvæ in the fall of the year are always found mining on the innermost leaves of the leaf-bundle, and there in the very latest formed leaf, just as the plant ceases growth before the winter sets in, the larva enters and transforms into the puparium. Plate II, Fig. 9, shows the larva as it enters this inner leaf and Plate II, Fig. 10, shows the leaf after the larva has entered and pupated.

The iris plant does not die down completely in the fall, but the center remains alive, and usually on each side of the plant are formed offsets which produce the new plants the following spring. These offsets then may be regarded as new individuals, while the center represents the overwintering form of the old plant. Both center and offsets are protected from exposure by the old leaves which in the spring gradually drop to the ground and disintegrate. Plate II, Fig. 1 shows a plant with several offsets.

In the spring when the plant resumes its growth, it is the little leaf in the center which contains the puparium, that causes the characteristic gall. The second leaf, crumpled, stands there as an indicator, showing that the gall was formed while the second leaf was still rapidly growing.

All the various pupæ, those found early in the summer, as well as those found in the fall, and those in the galls, were, after emergence, identified as *A. laterella*.

These observations then proved that this was not a case of alternation of different habits in two generations, but it showed that the fly is an essential leaf-miner, that the entire larval stage is spent in leaf-mining; that the majority of the larvæ pupated at the base of the leaves where no typical galls were produced; that only those larvæ that developed slowly, and entered the innermost leaf late in the fall at the time of cessation of growth, were instrumental in bringing about the gall-formation. It would probably be a fair estimate to assume that not over 20–25% of the larvæ enter the inner leaf and form galls.

Just when or how the stimulus is brought about which causes the gall formation has not been determined. There is no sign of swelling in the fall, even after the pupa stage has been reached, but as soon as the plant resumes growth in the spring, the swelling occurs.

The galls and mines are common wherever the iris occurs, often nearly every plant is found to be affected. The fact that the gall is formed on the innermost leaf, explains the reason why only one gall occurs on the same plant. However on October 23, 1917, I found several instances where two larvæ were present in the same plant, both apparently descending down to the much coveted spot, the newly formed inner leaf. In each such instance I found that the second larva remained in the mine about 10–45 mm. above the other one which had entered the usual place, the innermost leaf of the bundle. The "upper" larva had excavated an enlarged place and transformed to the puparium. These puparia, found in this position above the other, are always more perfect in shape than those in the gall-forming leaf.

Description of Stages.

The Egg.

(Plate I, Fig. 3).

When dissected out of the ovary, the egg presents a glistening white appearance and measures from .36-.40 mm. in length, and .13-.15 mm. in width in its greatest thickness. The egg is elongate oval, tapering considerably towards one end, and more or less rounded at the other. The egg appears smooth, no markings are visible from the outside.

The Larva.

(Plate I, Fig. 2, and Plate II, Fig. 5).

The young living larva is almost pure white, later becoming a glistening creamy white. A light yellow line running longitudinally through the center of the body represents the alimentary canal. The innermost leaves of the leaf-bundle of the iris, not having been exposed to the sunlight, are of a light yellow color, and the presence of this color material in the alimentary canal is seen through the transparent skin of the larva.

The larva is long, cylindrical, measuring from 5–7 mm. in length, when full grown, and about 1.3–1.6 mm. in diameter. It tapers slightly toward either end. The head bears the black mandible or rasping organ with four teeth, the first two somewhat larger than the other two. (Plate II, Fig. 2). On the dorsal surface of the first thoracic segment, just back of the head, are found the two thoracic spiracles, borne on short brown stalks, flaring at each end with from 14–17 lobed projections on the outer margin. These lobes or tubercles have at the tip little openings which lead to the tracheal tube attached at the base. (Plate II, Fig. 3).

On the ventral surface of the three thoracic segments occur small transverse ambulatory ridges. The ridge on the first thoracic segment is considerably larger than the following ones.

On the last abdominal segment are found two brown anal spiracular projections, each of which ends in three down-curved lobes, at the tip of which are also found the small spiracles. (Plate II, Fig. 4).

Just before pupation the larva shortens and thickens considerably, the little ambulatory ridges are completely withdrawn, while the spiracular projections are fully extended, and the larval skin changes into the puparium.

The Pupa.

(Plate I, Fig. 8).

The pupæ vary considerably in form and size. A comparison of a number of pupæ showed that they varied in length from 3.10–4.66 mm., in width from 1.10–1.5 mm., and in thickness from 1.0 -1.35 mm. Those that are found during the summer and early fall in the base of the leaf are more uniformly shaped being only slightly depressed; while those found later in the gall-forming leaf of the leaf bundle are always decidedly depressed and usually somewhat deformed, so that these pupæ in general appearance do not resemble the ones at the bases of the leaves and could be easily mistaken for another species.

The color of the puparium just after transformation is light brown, but later it becomes dark brown or almost black, especially those in the gall forming leaf; while the other puparia often remain rather light yellowish brown in color, though they also vary from dark brown to almost black.

During the transformation from the larval condition to the puparium, the thoracic and caudal spiracular projections are fully extended and transformed into two pairs of hardened hooks which help in holding the puparium in place in the plant.

The Adult.

(Plate I, Fig. 4).

The adults vary in length from 1.5–2.5 mm. The females are somewhat larger than the males. They are characterized by the proportionally large wings and the large antennæ, the antennæ of the males being larger than those of the females. The general ground color is shiny black or at least very dark brown. The thickened veins at the base of the wings, the halterers, proboscis, and joints of the legs are light yellow in color. Other lemon yellow markings occur along the sutures of the thorax and abdomen. The tibia and tarsi are yellowish brown. In the living flies the yellow markings are much more apparent than in the mounted dried specimens.

A technical description of the adult will be found in the Annals of the Entomological Society of America, VI, 300-301, 1913, by J. R. Malloch.

Specimens were found to be very numerous during the latter part of May till the middle or latter part of June, especially in the swamps and wet places where the iris grows in abundance.

EXPLANATION OF PLATES.

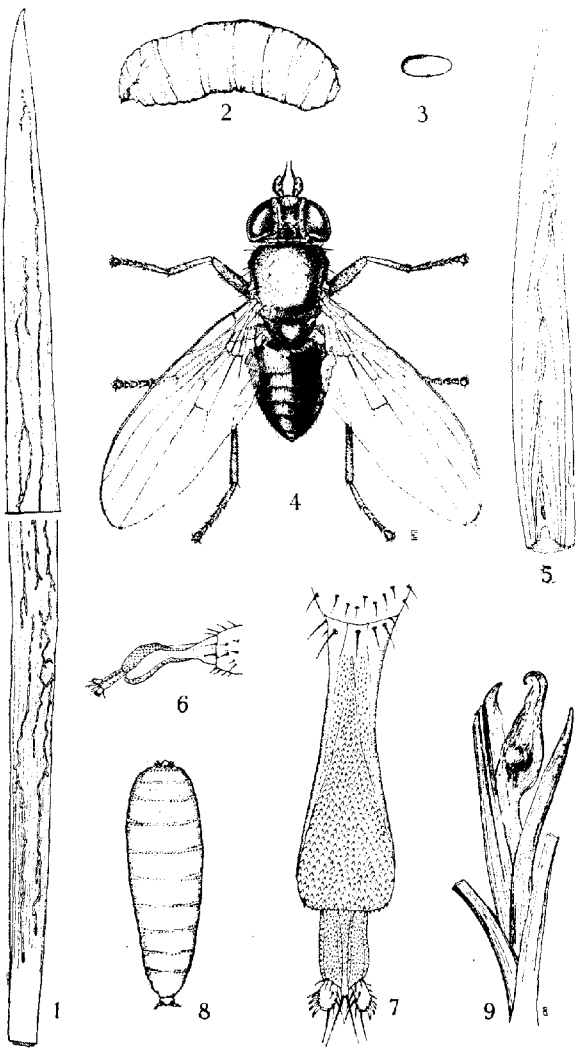
PLATE I.

Fig. 1. Outer leaf of iris showing the characteristic mines made by the larva of *Agromyza laterella*. The broken places in the mines indicate where the larvae have mined to the opposite side of the leaf.
Fig. 2. Full grown larva, contracted, just before pupation.
Fig. 3. Egg, dissected out of the ovary of the female.
Fig. 4. Adult fly, female.
Fig. 5. A leaf-bundle cut open to show the course of the larva as it mines down towards the new forming leaf.
Fig. 6. Ovipositor of female, side view.
Fig. 7. Ovipositor of female, dorsal view.
Fig. 8. Pupa, dorsal view.
Fig. 9. A young iris plant in spring, showing the leaf-gall. Notice the evidence of the mine, indicated by the unshaded part in the tip of the leaf, where the larva entered the tip of the gall-forming leaf.

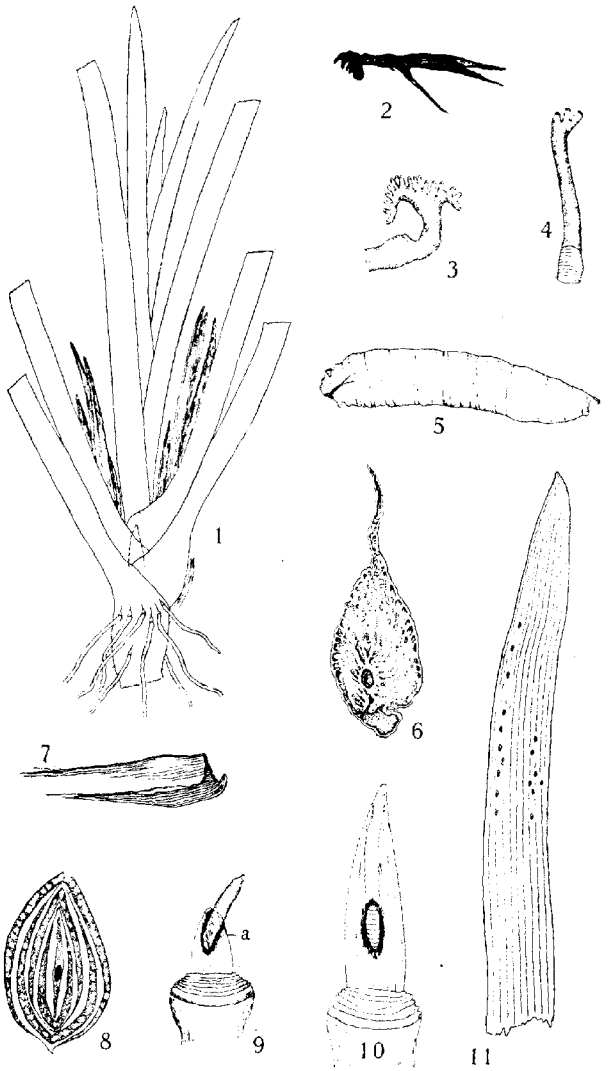
PLATE II.

Fig. 1. *Iris versicolor*, showing the condition of the plant in late fall or winter. The unshaded leaves represent the old dried or dead leaves. The shaded leaves represent the green offsets which will form next year's growth. In the center of the old plant is found the pupa. This center also remains alive. The innermost leaf is represented by the dotted lines.
Fig. 2. Mandible or rasping organ of the larva of the iris fly.
Fig. 3. Thoracic spiracle of the larva.
Fig. 4. Anal spiracle of the larva.
Fig. 5. Nearly full grown larva.
Fig. 6. Cross section of a gall, showing the pupa in the center. Note the spongy nature of the gall.
Fig. 7. Basal portion of an outer leaf of iris, showing the little swelling produced by the early maturing larvae which pupate in this portion of the leaf.
Fig. 8. Cross section of an iris plant at *a* in Fig. 9. This shows the arrangement of the leaf-bundle. Each sheath has been separated slightly from the others to bring out the structure more plainly.
Fig. 9. Outer sheaths of the leaf-bundle torn away to show the larva entering the inner leaf just before pupation.
Fig. 10. Same as Fig. 9, after the larva has entered and pupated.
Fig. 11. Egg punctures on the leaf. The structure of the ovipositor indicates that these are abrasions, rather than punctures.

NOTE—Figures 2, 4, 8 and 9 of Plate I, and Figures 6 and 7 of Plate II, have been drawn for me by Miss Ellen Edmonson, of Lawrence, Kansas. The remaining figures are my own.



P. W. Claassen.



P. W. *Claassen.*

A SYSTEMATIC STUDY OF THE ORGANISMS DISTRIBUTED UNDER THE NAME OF COCCOBACILLUS ACRIDIORUM D'HERELLE.

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A large amount of work has lately appeared dealing with d'Herelle's *Coccobacillus acridiorum* and his method of combating noxious grasshoppers. Some investigators have been able to confirm d'Herelle's results; others have been unable to do so, and since the entire subject seems to be in a state of confusion, I undertook a systematic study of a number of cultures which I obtained and which were distributed under the name of *Coccobacillus acridiorum* d'Herelle. As I suspected, some of the separate cultures proved to represent either different species or varieties of the same species. This fact may account for some of the contradictory views held by so many workers and it is my hope that this article will also demonstrate the need for attention to the ordinary principles of bacteriology which seem to be so persistently neglected by many entomologists.

In 1909 Dr. F. d'Herelle, while in the State of Yucatan, Mexico, noticed a heavy mortality in some flights of the destructive South American migratory locust *Schistocerca americana* Drury which arrived in the State from the borders of Guatemala. In 1911 the flights were all visited by this epizoötic and by 1912 it had reduced the number of locusts to such an extent that no invasion into Mexico occurred. In 1910 d'Herelle isolated a bacterium from the intestinal contents of cases of this disease. The organism was named by him *Coccobacillus acridiorum*. He was able to reproduce the disease and death by inoculating healthy grasshoppers with a culture of the Coccobacillus. These results were thought to be important by the Republic of Argentine which in 1911–12 requested d'Herelle to study the action of his bacterium against *Schistocerca paranensis* Burm, with a view towards its possible use in combating the pests. D'Herelle's methods apparently proved highly successful.

*In co-operation with the Bussey Institution of Harvard University (Bussey Institution No. 139).

D'Herelle's method consisted in obtaining a virulent form of his organism by twelve successive passages and then spraying dilutions of his cultures over sections of land infested by grasshoppers. The insects became infected by eating the contaminated food. The passages were performed by inoculation and the organism was considered to be virulent when death occurred in eight hours. The organism at its maximum virulence was supposed to cause death in three hours.

In 1913 Sergent and L'heritier tried out the efficacy of *Coccobacillus acridiorum* against *Stauronotus maroccanus* in Algeria. A general epidemic failed to develop in the field and the authors suggest that this failure may have been due to the presence of two autochthonous bacilli in the locusts which may have had an immunizing effect.

Lounsbury in 1913 attempted to combat *Zonocerus elegans* with d'Herelle's organism, in South Africa, but was unsuccessful.

Barber and Jones in 1913 performed field experiments with *Coccobacillus acridiorum* in the Philippines in an endeavor to check the injurious *Oedalens nigrofasciatus* De Geer and *Locusta migratoroides* R. and F. The experiments failed to show any satisfactory results.

During 1914–15 Béguet, Musso and Sergent conducted a campaign in Algeria against *Schistocerca peregrina* Oliv. These workers used d'Herelle's method in combination with the ordinary mechanical methods used for fighting the pests. It was found that d'Herelle's bacterium could not be used alone for the disease spreads too slowly. The combination of the two methods, however, proved helpful.

In 1915 Rorer reported that he had performed inoculation experiments with *Coccobacillus acridiorum* on *Schistocerca paranensis* and *Tropidacris dux* in Trinidad. He found that the organism was pathogenic to both insects and that the virulence could be increased by successive passages. Field experiments were not attempted.

Laines in 1915 reported that he was able to control grasshoppers in Honduras with d'Herelle's organism. A series of grasshoppers was inoculated from the abdominal substance of a series previously dead of the disease. By successive passages in this manner he claims to have obtained a high degree of virulence for the bacterium.

D'Herelle in 1915 controlled a severe outbreak of *Schistocerca peregrina* Oliv. in Tunisia by combining the use of his organism with the mechanical methods.

Velu and Bouin in 1915 reported that d'Herelle's method gave encouraging results in combating *Schistocerca peregrina* in Morocco.

During September, 1915, Dr. L. O. Howard, U. S. Bureau of Entomology, received what was termed two sub-cultures of d'Herelle's Coccobacillus from Dr. Cicilio Lopez Ponce of Honduras. In a letter written by Dr. Ponce the latter says: "Under instructions from the Secretary of the Honduran Commission of Agriculture, who lives in Tegucigalpa, I have the honor of sending you by this post, in a registered package, two tubes of a culture of the *Coccobacillus acridiorum* d'Herrlle. Some time ago I came to this city from the neighboring Republic of Salvador with the object of taking charge of a laboratory devoted to the cultivation and propagation of this parasite, and I am pleased to inform you that the results could not have been more satisfactory."

From their experiments in Canada (1916) Du Porte and Vanderleck concluded that: "The results of our work indicate that d'Herelle's biological method for the control of locusts cannot take the place of the methods now in use under the conditions which obtain in eastern Canada. Should the disease become established, its spread would be extremely slow, owing to the non-migratory and non-cannibalistic habits of the native species. The ideal conditions for the effective use of this method are those such as d'Herelle and others found in South America and North Africa where the locusts were in quickly moving swarms and were markedly cannibalistic in their habits. Indeed, most of these writers have emphasized the fact that "acridiophagy" is the chief factor in the spread of the disease. Another hindrance to the effective use of this method lies in the presence of several native strains of a coccobacillus identical with or closely related to d'Herelle's. These organisms are undoubtedly responsible for the immunity of the locusts to a mild infection of *Coccobacillus acridiorum*."

A perusal of the literature of the subject shows that five out of nine articles report encouraging field results by the use of d'Herelle's *Coccobacillus acridiorum*. These five reports all deal with the genus *Schistocerca* represented by the species *americana, paranensis*, and *peregrina*. The unsuccessful reports deal with a variety of grasshopper genera such as *Stauronotus, Zonocerus, Oedalens, Locusta* and *Melanoplus*. The bacterium may be very effective when used against certain species of the

genus *Schistocerca*, whereas it may be impossible to establish an epidemic in the field amongst members of certain other genera. All of the workers reported that the bacteria they used were pathogenic in their laboratory experiments. The field failures may be due to differences between the habits of the members of the genus *Schistocerca* and those of other genera. Differences between the climates of the separate countries where *Coccobacillus acridiorum* was used may also account for the varied results. The natural immunity of different genera or species is another factor worthy of consideration. Shall we therefore, owing to several failures, condemn d'Herelle's method under certain conditions? Obviously not.

D'Herelle and other workers who used his organism and methods successfully consider the following requirements the most necessary to the rapid spread of the disease in the field.

1. Cannibalistic habits of the insects (as very frequently exhibited by the genus *Schistocerca*).
2. Migratory habits (exhibited by the genus *Schistocerca*).
3. Dense hopper infestation.
4. Absence in hoppers of bacteria closely related to the *Coccobacillus acridiorum*. The presence of such organisms may have an immunizing effect.
5. Not an overabundance of normal food. When food becomes scarce due to the hopper infestation, the insects acquire cannibalistic habits which are favorable to the spread of the disease.
6. High temperature. The disease spreads more rapidly at the optimum temperature.
7. Absence of excessive rain. A heavy rain paralyzes the march of the epidemic.

All of the foregoing factors are undoubtedly highly important, but the writer should like to add one more requirement absolutely necessary for the study of this subject, namely:

8. The use of the same organism by the different investigators. Carefully controlled cultures should be distributed and used. The cultural and especially the bio-chemical characters of *Coccobacillus acridiorum* should be referred to constantly. Reference to morphological characters solely, as has been done so often, is worthless.

During December, 1915, I received from Dr. L. O. Howard, Chief of the U. S. Bureau of Entomology, two nutrient agar tubes containing pure cultures of a bacterium. These cultures were forwarded to Washington at the request of Dr. Howard by Dr. Cicilio Lopez Ponce, representing the Secretary of the Honduran Agricultural Commission of Tegucigalpa, Honduras.

The cultures were supposed to represent d'Herelle's *Coccobacillus acridiorum* and Dr. Ponce claimed to have obtained striking results with them in his field experiments.

During February, 1917, I received two cultures of the supposed *Coccobacillus acridiorum* direct from Dr. F. d'Herelle who is now at the Pasteur Institute, Paris. One culture was labeled "Souche Cham" which d'Herelle informed me is identical with the one I received from Dr. Ponce of Honduras. The other culture was labeled "Souche Sidi" and according to d'Herelle represented a strain of *Coccobacillus acridiorum* passed through a series of grasshoppers in Tunisia in 1915.

Also in February, 1917, I received through the kindness of Dr. C. Gordon Hewitt a pure culture of the supposed *Coccobacillus acridiorum* from Messrs. Du Porte and Vanderleck, who have performed some interesting experiments with this bacterium in eastern Canada. Dr. Hewitt, in a letter to me, stated that he received this culture direct from the Pasteur Institute in Paris.

I made a careful systematic study of these four cultures, compared them with one another as well as with the published descriptions of d'Herelle, and those of Du Porte and Vanderleck. The cultures differ from one another more or less. A table on page 25 shows the most salient differences and similarities. Since the bacterium sent by Ponce from Honduras seems to be an organism new to bacteriological literature, I have described it as a new species and named it *Bacillus poncei* in honor of Dr. Cicilio Lopez Ponce. I have also redescribed the three other cultures.*

Bacillus poncei is certainly not a Coccobacillus. It is a true bacillus, not in the least pleomorphic, no matter on what media it is grown. In this respect it certainly differs from d'Herelle's description. The latter emphatically states that his organism is highly pleomorphic, all stages between bacilli and cocci being observed in the same pure culture. *Bacillus poncei* produces much acid in milk; *Coccobacillus acridiorum*, according to d'Herelle, strong alkalinity. In so far as the production of ammonia and the fermentation (with gas) of dextrose, levulose and maltose are concerned the two organisms agree. D'Herelle's cultural and bio-chemical descriptions are so meagre that it is difficult to ascertain his exact meaning.

* The detailed descriptions will be found appended to this article.

Culture "Souche Cham" is highly pleomorphic. Milk is rendered acid, but is not coagulated. D'Herelle's organism should render milk alkaline and coagulate it. In the production of ammonia and in the fermentation (with gas) of dextrose, levulose and maltose, the two organisms agree. As can be seen from the table on page 25 "Souche Cham" differs greatly from *B. poncei*. Strange as it may seem, "Souche Sidi" and "Souche Cham," the two cultures sent by d'Herelle himself differ from one another. "Souche Sidi" is slightly pleomorphic, but this character is not nearly so pronounced as is the case with "Souche Cham." "Souche Sidi" coagulates milk, whereas "Souche Cham" does not. "Souche Sidi" reduces litmus milk; "Souche Cham" does not. "Souche Sidi" does not ferment (with gas) lactose and adonit; "Souche Cham" ferments both of these carbohydrates with the fermentation of gas (Hydrogen $+CO_2$). "Souche Sidi" does not tally with d'Herelle's description nor with *B. poncei*.

Du Porte and Vanderleck's culture agrees with the culture I received from d'Herelle under the name of "Souche Sidi." Curiously enough, however, my description of Du Porte and Vanderleck's culture does not entirely agree with the description given by these writers. I agree with them in so far as the morphological characters are concerned. My gelatin stabs, however, showed liquifaction after about eight weeks; they claim that gelatin is not liquified. My litmus was reduced; Du Porte and Vanderleck claim "no reduction." I am unable accurately to interpret the results of Du Porte and Vanderleck's carbohydrate fermentation tests for the reason that they do not state whether fermentation was accompanied by the formation of gas and acid or merely acid alone. I assume they mean gas formation, in which case, as will be seen from the table on page 25, our lactose tests differ.

What can one conclude from these results? Only this, namely, that different organisms are being distributed under the name of *Coccobacillus acridiorum*. I should, moreover, like to suggest that d'Herelle redescribe the organism concerned in his grasshopper epidemic more accurately so that other workers may know to which bacterium reference is made. Judging from the morphological descriptions alone I think d'Herelle has reference to the highly pleomorphic organism which he sent me labeled "Souche Cham," but of course, this is merely a conjecture. Du Porte and Vanderleck found several pleomorphic organisms native to grassphopers in eastern Canada.

TABLE SHOWING MOST STRIKING DIFFERENCES AND SIMILARITIES BETWEEN CULTURES DISTRIBUTED UNDER THE NAME COCCOBACILLUS ACRIDIORUM D'HERELLE.

	Morphology	Gelatin Stab	Milk	Litmus Milk	NH_3 on Potato	Nitrate Reduction	Indol	Dextrose	Levulose	Saccharose	Maltose	Lactose	Mannit	Adonit	Dulcit
Bacillus potet from Honduras	Bacilli	No liquifaction	Strong acidity. Coagulation.	Strong acidity Coagulation Reduction	+	+	0	+	+	0	+	+	+	+	0
"Souche Sicile" from d'Herelle	Bacilli and coccoid forms	Liquifaction	Weak acidity. Coagulation.	Weak acidity Coagulation Reduction	+	+	0	+	+	+	+	0	+	0	0
Culture sent by Da Porte & Vanderleck	Bacilli and coccoid forms	Liquifaction	Weak acidity. Coagulation.	Weak acidity Coagulation Reduction	+	+	0	+	+	+	+	0	+	0	0
"Souche Chanvy" from d'Herelle	All stages between bacilli and diplococci	Gas. Liquifaction	Weak acidity. No coagulation.	Weak acidity No coagulation No reduction	+	+	0	+	+	+	+	+	+	+	0
d'Herelle's Original Description	All stages between bacilli and coccoi	Not mentioned	Strong alkalinity. Coagulation.	Not mentioned	+	Not mentioned	Not mentioned	+	—	Not mentioned	+	Not mentioned	Not mentioned	Not mentioned	Not mentioned
Da Porte & Vanderleck's Description	Bacilli and diplococci	No liquifaction	Acidity. Coagulation.	Weak acidity Coagulation No reduction	Not mentioned	Not mentioned	0	+	Not mentioned	+	Not mentioned	+	Not mentioned	0	0

EXPERIMENTATION WITH CULTURES.

In order to test the pathogenicity of the separate cultures laboratory experiments were performed with *Bacillus poncei and with d'Herelle's cultures labeled "Souche Cham" and "Souche Sidi." I attempted no experiments with the culture* obtained from Messrs. Du Porte and Vanderleck for the reason that my systematic study showed this culture to be identical with d'Herelle's "Souche Sidi" strain.

In all of my experiments the most painstaking bacteriological technicalities were observed, so I shall not undertake to describe all of the tiresome and well known methods in vogue such as using sterile instruments, etc., for injecting and operating upon a grasshopper. Suffice it to say, that sterile containers in the form of battery jars were found extremely useful in performing my experiments. Glass plates covered the jars in order to keep the hoppers from jumping out. These plates had the further advantage of keeping the corn leaves, with which we fed the insects, fresh. Prior to the injection the hoppers were always washed with 95% alcohol. This must not be used too freely, otherwise, the grasshoppers may die and after its use one must wait a minute or so for the alcohol to evaporate before injecting. A small amount of alcohol entering the wound, however minute, caused by the hypodermic needle usually ends fatally. The inoculations were always performed between the metathorax and the first abdominal segment on the ventral side. In order to avoid rupturing the gut or otherwise injuring the insect, two operators are absolutely necessary to perform successful inoculations. One person must carefully, but firmly hold the insect while the other inoculates. I performed a number of tests in order to determine whether my technical precautions were sufficient and I found them satisfactory. For example: I washed off a large series of grasshoppers with alcohol and then injected with sterile water. Some of the insects I permitted to live until they seemed to die of natural causes; others I killed after periods of one and two weeks in order to inoculate culture tubes with some blood obtained by bathing the trochanter and femur with alcohol and then breaking the joint by a swift movement. The culture tubes remained perfectly sterile.

Experiments with Bacillus poncei.

On reviewing the tables which illustrate my experiments with *B. poncei* and the other bacteria investigators in this subject may wonder why I used females more often in preference to males. The reasons are these: Female grasshoppers are much larger than the males and consequently easier to handle. Moreover, they seem to be hardier and withstand the alcohol bath and hypodermic needle much better than the males. Finally, the females naturally live longer which is, of course, a decided advantage in any experiment.

Another inconsistency in my experiments seems evident from the fact that at times I used a smaller or a larger number of animals in one experiment than in another. This was found necessary for the reason that large numbers of female grasshoppers of the desired species, sufficiently mature for experimentation, were sometimes difficult to find in the region where my laboratory experiments were performed.

The tables given on pages 38–41 are self-explanatory. The insects were always inoculated with one drop (1/10 c. c.) of the particular fluid. The emulsion of the six months old agar culture of *B. poncei* given in Table I was prepared by adding 10 c. c. of sterile water to the old culture and shaking the tube vigorously. The emulsions of the intestinal contents of dead animals were prepared by dissecting out the intestines under aseptic conditions and triturating in sterile test tubes containing 5 c. c. of sterile water. This material, owing to the fact that it contained shreds of tissue was filtered in a sterile filter especially prepared for the experiments and from which unfiltered air was excluded.

Tables II, III and IV represent passage infections modeled after the experiments performed by other workers. By an examination of Tables I–IV it would seem that I had increased the virulence of *B. poncei*, while the deaths represented on Tables I and II extend over a long period of time; at the second and especially at the third passage Tables III and IV, the number of days elapsing between infection and death are considerably shortened.

The optimist would at once proclaim this as evidence for increase in virulence, but such is not the case. The three animals dead in the last experiment were carefully examined

and an earnest attempt was made to recover *B. poncei*, but I utterly failed. I inoculated a variety of media from the blood, from various tissues and from the intestines. I plated from these media and tested all suspicious looking colonies on the required media, (media given in my descriptions of organism) in the sugar tubes and performed the nitrate and indol tests as well but without success. About a half-dozen other organisms were found, but *B. poncei* failed to reveal itself. What killed the grasshoppers? The five deaths represented on Table I were probably due to *B. poncei*, but the deaths in the three passage infections were due to the careless way in which these experiments were carried out. Since this method has been used by practically all workers on this subject, I wish to point out its absolute worthlessness. Grasshopper intestines, as a large number of observations convinced me, are not only often full of gregarines and flagellates, but contain many species of bacteria (intestinal flora). By performing such passage infections as outlined in my tables one simply inoculates the animals with an indefinite quantity of intestinal flora. No wonder the animals succumbed. What then became of *B. poncei?* This bacterium was either destroyed by the countless other introduced bacteria or was killed by the grasshopper blood cells (phagocytocis) or other immunity principles. If the grasshoppers are to be inoculated in the body cavity why should so many investigators choose the intestines for further passages? Why not perform the passages with the blood? Of course, a sufficient number of the organisms introduced should cling to the outside of the intestines when these are removed, but other organisms within the intestines are likewise introduced. I also failed to obtain pure cultures of *B. poncei* by resort to blood passages on the animals I used (*Melanoplus femur-rubrum* and *Encoptolophus sordidus*) for the reason that the blood seems to act antagonistically towards the bacterium in question and destroys it in most cases. Nevertheless, other organisms are carried along since the toxins or other products introduced cause a disturbance of some sort which in turn causes the gut of the grasshopper to rupture liberating the intestinal flora into the body cavity.

Tables V, VI and VII represent another series of experiments performed along the same lines as the preceding. The results were exactly similar. I know of no way in which passage

infections can be performed in this manner. Tables VIII, IX and X represent another series of passages performed on another species of grasshopper, *Encoptolophus sordidus*. Even after the 1st passage I failed to recover *B. poncei*. Strange as it may appear, I recovered *B. poncei* from one animal dead in the 2nd passage.

Table XI represents thirty-five animals (*M. femur-rubrum*) inoculated with a twenty-four hour bouillon culture of *B. poncei*. The organism in question was recovered only three times.

Table XII demonstrates what is meant by the rupture of the gut after a foreign toxin or protein is introduced into the blood. In order to see whether I was rupturing the intestines myself by introducing the hypodermic needle, I injected a large series of grasshoppers with a dead culture of *B. poncei*. After three days I inoculated some bouillon tubes with some of the blood taken from these animals. The tubes remained perfectly sterile.

Tables XIII and XIV represent experiments on infection by feeding. Here the organisms were introduced into the alimentary tract. If *B. poncei* is pathogenic at all, I thought, this would be the most natural method of infection. I failed, however, to recover the organism either from the feces, from the living infected animals, or from the alimentary tract of the dead. From what did these animals die? Possibly from endotoxins liberated from *B. poncei*, which was destroyed within the grasshopper stomach and intestines.

The method of spraying the culture on the food foliage consisted in diluting the culture one-half with sterile water and spraying with a fine atomizer until the leaves were visibly wet.

Conclusions on Experiments with B. poncei.

I conclude from the foregoing experiments that *B. poncei* is pathogenic to *Melanoplus femur-rubrum* and *Encoptolophus sordidus*. In most cases, however, I failed to recover the organism from the blood, the alimentary tract and from the feces. My experiments lead me to believe that insects can develop immunity principles which can more or less successfully cope with certain foreign organisms. The following experiment will further assist in substantiating this view. October 12, 1916, I inoculated six female *M. femur-rubrum* with a twenty-four

hour bouillon culture of *B. poncei*. October 13th the animals were all alive. I pulled out one metathoracic leg from each animal and permitted a drop of blood from each to flow into a nutrient bouillon tube. Three tubes were kept at room temperature and three were incubated, yet all six remained perfectly sterile. Stained smears of some of the blood also failed to reveal any micro-organisms. Sooner or later, I think, the gut would have ruptured liberating the intestinal flora into the body cavity, so I thought it best to make the tests the second day.

I further conclude that passage infections performed by using the alimentary tract are hopeless on account of the extensive flora. Blood passages, with *B. poncei*, were likewise useless, in most cases, for the reason that the gut ruptured after a short time. Passages by means of the blood are possible with other bacteria, however, as I will show later.

Experiments with Cultures "Souche Cham" and "Souche Sidi."

The infection experiments with "Souche Cham" and "Souche Sidi" were much more satisfactory than those with *B. poncei*. In regard to "Souche Cham," I successfully performed two passages, but curiously enough, as can be seen from Tables XV–XVII (1 and 2), obtained no increase in virulence. Perhaps if I had measured the time between inoculation and death in hours instead of in days, I might have noticed something, but many deaths unfortunately occurred during the night. However, measurement of time in days is sufficient and if a marked increase in virulence had manifested itself, I surely would have noticed it.

The gut of *M. atlanis* never ruptured, so the blood or muscle tissue could readily be used as a basis for further inoculations. In no case, however, can extracts from the stomach or the intestines be used for further passages. A series of examinations conclusively proved that these are invariably contaminated even in perfectly normal looking animals.

Tables XVIII and XIX represent experiments dealing with food infections. *M. atlanis* was also the subject for these tests. In general the time between infection and death is somewhat extended which is to be expected in this mode of experiment,

still it seems to me that the organism acts very quickly. These "per os" infections really mean more than the inoculation experiments for the reason that it is the natural way in which the bacterium would invade the insect. Of course, laboratory passages, where pure recoveries are required, are impossible to perform by this method of infection unless one plated between each infection. Since my experiments showed the futility of passages, in so far as increase in virulence is concerned, I did not see any advantage in doing an extra amount of tedious work. It seems to me that the organism is sufficiently virulent even in old cultures, so that if one could succeed in establishing a center of infection in the field an epidemic would soon follow provided certain conditions were favorable.

Tables XX and XXI also represent food infections. *M. bivittatus* was the subject. If it is permissible to judge from two experiments the organism does not seem to be so pathogenic to this insect. A number of insects in the XX experiment succumbed to parasitism by *Mermis ferruginea*, a nematode.

Table XXII represents the same sort of an experiment as the preceding with the exception that *M. femur-rubrum* was the subject. "Souche Cham" also does not seem to be as highly pathogenic to this species as it is to *M. atlanis*.

Table XXIII represents an inoculation experiment with "Souche Sidi." *M. atlanis* was the subject. The period from infection to death extends over a period of six days. This seems to show that "Souche Sidi" is not as pathogenic as "Souche Cham."

Table XXIV represents a food infection experiment with the same culture and the same subject. The period from infection to death is also, in general, prolonged. Two animals died naturally although I am certain they became infected.

In all of the food infection experiments the grasshoppers were given barely enough leaves in order to insure their eating everything in 12–24 hours.

Table XXV represents a food infection experiment with "Souche Sidi." The subject in this case was *M. bivittatus*. The pathogenicity of "Souche Sidi" for this species seems to be the same as for *M. atlanis*.

Suitable checks accompanied all of my experiments. These always died of old age or of *Mermis* parasitism, but seemed not to suffer naturally from any endemic disease. At times I found some checks prematurely dead, but I traced this to CO_2 asphyxiation and on replacing my glass plates, which covered the battery jar containers, with cheese-cloth tops, I overcame this difficulty. The glass plates are splendid, however, unless one confines too many insects in one jar.

As can be seen on examining the tables, I performed a large series of post mortem tests. This means that stained smears were studied and that the material was "plated out," colonies isolated and the species studied on different media, and their bio-chemical characters in carbohydrates, etc., observed. Of course, some of these final tests were finished long after the conclusion of the grasshopper season. It is absolutely impossible to perform in a short time, the huge amount of work which experiments of this sort require.

Conclusions on experiments with cultures "Souche Cham" and "Souche Sidi."

1. "Souche Cham" is pathogenic to *M. atlanis*, *M. bivittatus* and *M. femur-rubrum.*

2. "Souche Cham" is not as pathogenic to *M. bivittatus* and *M. femur-rubrum* as to *M. atlanis.*

3. Passage infections with "Souche Cham" were possible, but no increase in virulence was observed.

4. The gut of *M. atlanis* does not rupture, and for this reason the blood and muscle tissue can be used for passage infections.

5. Extracts from the stomach or intestines can not be used for passage infections.

6. In food infections the time between inoculation and death is somewhat extended.

7. "Souche Cham" and "Souche Sidi" are quite virulent even in old cultures.

8. "Souche Sidi" is not as pathogenic to *M. atlanis* and *M. bivittatus* as "Souche Cham."

9. No passage infections with "Souche Sidi" were attempted.

FIELD EXPERIMENTS.

Melanoplus atlanis is a serious pest in certain regions of the State of Vermont. Since this species occurs in dense swarms and since it acquires cannibalistic habits when natural food becomes scarce, I thought it would be splendid material for field work. Mr. A. M. Wilcox and I have instituted a large series of field experiments with cultures "Souche Cham" and "Souche Sidi" in Vermont, but we wish to await the passage of at least another season before drawing any conclusions. The hurried method of rushing into print field observations dealing with a single season's work is deplorable. The amount of work which is necessary before coming to any conclusions at all is so immense that an army of trained workers co-operating in every possible way could not obtain final results after a single season's work.

Culture sent by Dr. Cicilio Lopez Ponce of Honduras under the name of *Coccobacillus acridiorum:*

Bacillus poncei sp. nov.

Morphology. From 1½% nutrient agar stroke 24 hours old, long rods. From 1½% potato agar stroke 24 hours old, long rods and some short rods. From milk 48 hours old, many short rods. Average length 2.2μ. Average width .9μ. Motile. Gram negative. Stains readily.

Nutrient agar stroke. 1½%. Neutral. Growth moderate, spreading, flat, glistening, smooth, white, opaque, odor absent, butyrous, medium unchanged.

Potato agar stroke. 1½%. Neutral. Growth very luxuriant, arborescent, flat, glistening, smooth, white, opaque, odor absent, butyrous, medium unchanged.

Potato. Growth abundant, spreading, flat, glistening, smooth, white, odor absent, butyrous, medium unchanged.

Gelatin stab. Growth best at top, beaded, no liquifaction, medium unchanged.

Nutrient broth. Neutral. Pellicle, clouding strong, no clearing after 15 days, odor absent, slight sediment.

Milk. Acid. Coagulation in six days. Extrusion of whey in six to ten days, no peptonization, color of medium unchanged.

Litmus milk. Acid, coagulation, prompt reduction.

Gelatin colonies. Growth slow, white, round, slightly raised, edge entire, no liquifaction.

Agar colonies. Growth slow, white, round, smooth, raised slightly, edge entire, amorphous, diameter 4 mm.

Ammonia production. Feeble.

Nitrate solution. Nitrates reduced to nitrites.
Indol production. Absent.
Hydrogen sulphide production. Absent.
Fermentation of carbohydrates with gas.

Dextrose	+	Lactose	+
Levulose	+	Mannit	+
Saccharose	O	Adonit	+
Maltose	+	Dulcit	O

Pathogenicity. Pathogenic to *Melanoplus femur-rubrum, Encoptolophus sordidus,* and *Gryllus pennsylvanicus.* Pathogenicity not tested out on any other forms.

Culture sent by d'Herelle under the name *Coccobacillus acridiorum.* Culture labeled "Souche Cham":

Morphology. From 1½% nutrient agar stroke 48 hours old, small diplococci. All very uniform. No bacilli. In water of condensation all transition forms between diplococci and bacilli. Highly polymorphous.* From milk 48 hours old, small diplococci, no bacilli. From bouillon 48 hours old, all intermediate stages between true bacilli and coccus forms. Nutrient bouillon is a favorable medium for the development of the bacillus forms. Solid media like nutrient and potato agar are favorable for the development of the diplococcus forms. This can be easily demonstrated by transferring from the liquid to the solid medium and vice versa. Diameter of cocci .6μ. Length of bacilli .7-1.5μ. Motile. Gram negative. Stains readily.

Nutrient agar stroke. 1½%. Neutral. Growth abundant, spreading, flat, glistening, smooth, opaque, odor absent, butyrous, color of medium unchanged.

Potato agar stroke. 1½%. Neutral. Growth very luxuriant, spreading, flat, glistening, smooth, opaque, odor absent, butyrous, color of medium unchanged.

Potato. Growth abundant, whitish.

Gelatin stab. Growth uniform, beaded, gas, liquifaction, medium unchanged.

Nutrient broth. Ring, slight pellicle, clouding strong, sediment abundant, odor absent, no clearing after fifteen days.

Milk. Weak acidity, no coagulation, color of medium unchanged.

Litmus milk. Weak acidity, no coagulation, no reduction.

Gelatin colonies. Growth rapid, round, convex, edge entire, gas, diameter of colony .5-1 mm.

Nutrient agar colonies. Growth rapid, round, smooth, flat, edge entire, amorphous, diameter of colony 2.5-3 mm.

Ammonia production. Positive.

Nitrate solution. Nitrates reduced to nitrites.

Indol production. Negative.

*For an interesting article on pleomorphism see: Studies in pleomorphism in Typhus and other diseases by Edward C. Hort. Abstract in Jour. Royal Micros. Soc., December, 1916.

Hydrogen sulphide production. Negative.
Fermentation of carbohydrates with gas.

Dextrose	+	Lactose	+
Levulose	+	Mannit	+
Saccharose	+	Adonit	+
Maltose	+	Dulcit	O

Pathogenicity. Pathogenic to *Melanoplus atlanis*, *Melanoplus bivittatus*, and *Melanoplus femur-rubrum*. Pathogenicity not tested out on any other forms.

Culture sent by d'Herelle under the name *Coccobacillus acridiorum*. Culture labeled "Souche Sidi":

Morphology. From 1½% nutrient agar stroke 48 hours old, short bacilli dominant forms; some coccoid forms. In water of condensation bacillus forms typical. From milk 48 hours old, bacillus forms dominant; some coccoid forms. From bouillon 48 hours old, typical bacillus forms dominant; few coccoid forms. Not as polymorphous as culture "Souche Cham." Length of bacilli .8-1.5μ. Motile. Gram negative. Stains readily.

Nutrient agar stroke. 1½%. Neutral. Growth abundant, spreading, flat, glistening, smooth, opaque, odor absent, butyrous, color of medium unchanged.

Potato agar stroke. 1½%. Neutral. Growth very luxuriant, spreading, flat, glistening, smooth, opaque, odor absent, butyrous, color of medium unchanged.

Potato. Growth abundant, whitish.

Gelatin stab. Growth uniform, beaded, liquifaction, medium unchanged.

Nutrient broth. Ring, slight pellicle, clouding strong, sediment abundant, odor absent, no clearing after fifteen days.

Milk. Weak acidity, coagulation delayed, extrusion of whey, no peptonization, color of medium unchanged.

Litmus milk. Weak acidity, coagulation, extrusion of whey, reduction complete.

Gelatin colonies. Growth rapid, round, convex, edge entire, no liquifaction, diameter of colony .5-1 mm.

Nutrient agar colonies. Growth rapid, round, smooth, flat, edge entire, coarsely granular, diameter of colony 2.5-3 mm.

Ammonia production. Positive.

Nitrate solution. Nitrates reduced to nitrites.

Indol production. Negative.

Hydrogen sulphide production. Negative.

Fermentation of carbohydrates with gas.

Dextrose	+	Lactose	O
Levulose	+	Mannit	+
Saccharose	+	Adonit	O
Maltose	+	Dulcit	O

Pathogenicity. Pathogenic to *Melanoplus atlanis* and *Melanoplus bivittatus*. Pathogenicity not tested out on any other forms.

Culture sent by Messrs. Du Porte and Vanderleck of Canada, who received same from d'Herelle under the name of *Coccobacillus acridiorum:*

Morphology. From 1½% nutrient agar stroke 48 hours old, short bacilli dominant forms; some coccoid forms. In water of condensation bacillus forms typical. From milk 48 hours old, bacillus forms dominant; some coccoid forms. From bouillon 48 hours old, typical bacillus forms abundant; few coccoid forms. Not as polymorphus as culture "Souche Cham." Length of bacilli .8-1.5μ. Motile. Gram negative. Stains readily.

Nutrient agar stroke. 1½%. Neutral. Growth abundant, spreading, flat, glistening, smooth, opaque, odor absent, butyrous, medium unchanged.

Potato agar stroke. 1½%. Neutral. Growth very luxuriant, spreading, flat, glistening, smooth, opaque, odor absent, butyrous, medium unchanged.

Potato. Growth abundant, whitish.

Gelatin stab. Growth uniform, beaded, liquifaction, medium unchanged.

Nutrient broth. Ring, slight pellicle, clouding strong, sediment abundant, odor absent, no clearing after fifteen days.

Milk. Weak acidity, coagulation delayed, extrusion of whey, no peptonization, color of medium unchanged.

Litmus milk. Weak acidity, coagulation, extrusion of whey, reduction complete.

Gelatin colonies. Growth rapid, round, convex, edge entire, no liquifaction, diameter of colony .5-1 mm.

Nutrient agar colonies. Growth rapid, round, smooth, flat, edge entire, coarsely granular, diameter of colony 2.5-3 mm.

Ammonia production. Positive.

Nitrate solution. Nitrates reduced to nitrites.

Indol production. Negative.

Hydrogen sulphide production. Negative.

Fermentation of carbohydrates with gas.

Dextrose	+	Lactose	0
Levulose	+	Mannit	+
Saccharose	+	Dulcit	0
Maltose	+	Adonit	0

Pathogenicity. Pathogenic to ***Melanoplus atlanis*** and ***Melanoplus bivittatus.*** Pathogenicity not tested out on any other forms.

Original description by d'Herelle of *Coccobacillus acridiorum:*

Morphology. Media from which the morphological observations were made not mentioned. Short bacillus, slightly oval, very polymorphous. Cocci .6μ, bacilli .4-.6μ by .9-1.5μ. Motile, peripheral flagellæ. Gram negative, stains readily.

Potato. Growth creamy. Water of condensation sirupy, reaction strongly alkaline.

Gelatin. Not liquified.

Nutrient broth. Development rapid at 37°. Clouding from fourth hour on. After several days a very light veil appears. Bouillon clears after three weeks, producing a sediment. A young culture agitated produces silky waves. Odor of Liebig's extract. Rendered strongly alkaline.

Milk. Coagulated and rendered strongly alkaline.

Nutrient agar colonies. Visible after 12 hours. After 18 hours they are 2–3 mm. in diameter. Circular, waxy. Below surface spherical, whitish, opaque.

Fermentation of carbohydrates.

Dextrose	+	Organism renders medium containing one
Levulose	+	of these sugars slightly acid than
Maltose	+	alkaline.
Galactose	+	

Oxygen requirements. Facultative anaerobe.

Pathogenicity. Pathogenic to various Acrididæ, ants and caterpillars.

Description by Du Porte and Vanderleck of culture sent to them from d'Herelle under the name *Coccobacillus acridiorum:*

Morphology. From agar slope 20 hours old, short rods or cocci, some oval, polymorphous. 0.7–1.0μ. In milk culture they appear often as diplococci. Motile. Gram negative. Amylgram positive. Stain readily.

Agar stroke. Abundant growth, spreading, flat, glistening, smooth, dirty white to bluish white, opaque, butyrous, medium unchanged. On 1% agar the cultures are arborescent and transparent.

Potato. Abundant growth, spreading, flat, glistening, smooth, butyrous; color from dirty white to yellow.

Gelatin stab. Uniform growth, line of puncture filiform. No liquifaction, medium unchanged. Stab brownish yellow.

Nutrient broth. Pellicle or ring, turbidity, slight sediment, no clearing after 14 days, odor of beef extract.

Milk. At first gas production without coagulation. Delayed coagulation in 2–8 days, acid reaction after 8 days, no peptonization, medium unchanged, no extrusion of whey.

Litmus milk. Gas production, weak acidity, no reduction. After four days partial to complete coagulation, acid.

Gelatin colonies. Growth slow, round, raised, edge entire, yellow. Three weeks, 2 mm. in diameter, yellow white. No liquifaction.

Agar colonies. Rapid growth, irregular, round, smooth, flat, edge entire, amorphous, dirty white to blue, transparent. Growth more restricted on 1½% than on 1% agar.

Aesculin bilesalt agar. Weak field after 24 to 48 hours.

Neutral red bilesalt agar. Strong fluorescence, red spreading.

Indol production. Negative.

Fermentation of carbohydrates.

Dextrose	+	Rafinose	+
Saccharose	+	Arabinose	+
Lactose	+ (weak)	Adonit	0
Galactose	+	Dulcit	0
Muscle sugar	+		

Pathogenicity. Pathogenic to locusts and grasshoppers. Injection fatal within 24 hours.

TABLE I.

Ten animals injected with an emulsion of a 6 months old agar culture of *B. poncei*. ♀ ♀ *M. femur-rubrum* used.

No. of days....	1	2	3	4	5	6	7	8	9	10	11	12	13	14
No. of deaths..	1				1			1					1	1

5 lived

TABLE II.

Eight animals injected with an emulsion of intestinal contents of animal dead on 8th day. ♀ ♀ *M. femur-rubrum* used. 1st passage.

No. of days.....	1	2	3	4	5	6	7	8	9	10
No. of deaths.....		1				2	1	2		1

1 lived

TABLE III.

Three animals injected with an emulsion of intestinal contents of an animal dead on the 6th day. ♀ ♀ *M. femur-rubrum* used. 2nd passage.

No. of days.....	1	2	3	4	5
No. of deaths.....			1	1	1

TABLE IV.

Three animals injected with an emulsion of intestinal contents of last one dead in previous experiment. ♀ ♀ *M. femur-rubrum* used. 3rd passage.

No. of days.....	1	2	3	4
No. of deaths.....		3		

The three animals dead on 2nd day were "tested." *B. poncei* not recovered. Other organisms recovered.

TABLE V.

Eight animals injected with a 24-hour culture of *B. poncei* in nitrate solution. ♀ ♀ *M. femur-rubrum* used.

No. of days.....	1	2	3	4	5
No. of deaths....			2		2

4 lived for a month

TABLE VI.

Three animals injected with an emulsion of intestinal contents of last two dead in previous experiment. ♀ ♀ *M. femur-rubrum* used. 1st passage.

No. of days.....	1	2	3	4
No. of deaths.....		2	1	

TABLE VII.

Three animals injected with an emulsion of intestinal contents of last one dead in previous experiment. ♀ ♀ *M. femur- rubrum* used. 2nd passage.

No. of days	1	2	3	4
No. of deaths		3		

Three animals dead in last experiment "tested." *B. poncei* not recovered. Other organisms recovered.

TABLE VIII.

Five animals injected with a 24-hour culture of *B. poncei* in nitrate solution. ♀ ♀ *Encoptolophus sordidus* used.

No. of days	1	2	3	4	5	6	
No. of deaths		2	1			1	1 lived

TABLE IX.

Five animals injected with an emulsion of intestinal contents of last one dead in previous experiment. ♀ ♀ *Encoptolophus sordidus* used. 1st passage.

No. of days	1	2	3	4	5	6	7	
No. of deaths			1			1	1	2 lived

Animals dead on 6th and 7th days "tested." *B. poncei not* recovered. Other organisms recovered.

TABLE X.

Five animals injected with an emulsion of intestinal contents of last one dead in previous experiment. ♀ ♀ *Encoptolophus sordidus* used. 2nd passage.

No. of days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
No. of deaths								1		1		1					1		1

Animals dead on 12th, 17th and 19th days "tested." *B. poncei* recovered from animal dead on 12th day. Other organisms recovered from remaining two tests.

TABLE XI.

Thirty-five animals injected with a 24-hour bouillon culture of *B. poncei*. ♀ ♀ *M. femur-rubrum* used.

No. of days	1	2	3	4	5	6	7	8	9	10	11
No. of deaths		9	7	12	4	2					1

Three dead animals "tested" on 4th day as well as last seven dead. Recovered *B. poncei* three times. Other organisms recovered in remaining tests.

TABLE XII.

Nineteen animals injected with a 24-hour bouillon culture killed by sterilizing in autoclave. Sterility verified by inoculating various media. ♀ ♀ *M. femur-rubrum* used.

No. of days	1	2	3	4	5	6	7	8	9	10	11	12	13	14
No. of deaths		2		3			9	1	1	1	1			1

Six animals "tested." *B. poncei* not recovered. Two tests showed cultural sterility; four showed presence of other organisms.

TABLE XIII.

Nine animals enclosed in a battery jar and food sprayed with a 48-hour culture of *B. poncei*. Proportions of sexes not noted, but ♂ ♂ and ♀ ♀ of *M. femur-rubrum* used.

No. of days	1	2	3	4	5	6	7	8	0	10
No. of deaths						2	2			5

Five dead animals "tested." *B. poncei* not recovered. Other organisms recovered.

TABLE XIV.

Eight animals enclosed in a battery jar and food sprayed with a 48-hour culture of *B. poncei* in nitrate solution. Four ♂ ♂ and four ♀ ♀ *M. femur-rubrum* used.

No. of days.....	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No. of deaths...				1		2	1			1		1					1			1

Three dead animals "tested." *B. poncei* not recovered. Other organisms recovered.

TABLE XV.

Twenty animals injected with a 17-hour bouillon culture of *Coccobacillus acridiorum* "Souche Cham." ♀ ♀ *M. atlanis* used.

No. of days.....	1	2	3	4
No. of deaths.....		17	3	

Last three dead "tested." Piece of femural muscle removed aseptically and dropped into culture tube. Pure culture of "Souche Cham" obtained.

TABLE XVI.

Two out of seventeen dead on 2nd day in previous experiment taken and femural muscle triturated in 10 c. c. sterile H_2O. Eight ♀ ♀ *M. atlanis* injected. 1st passage.

No. of days....	1	2	3	4	5	6	7	8
No. of deaths..		5	3					

Tests made from blood and femural muscle of dead animals reacted positively for "Souche Cham." No other organisms found.

TABLE XVII (No. 1 and 2).*

Eight animals injected from one dead on 3rd day in previous experiment and eight injected from another dead the same day. Femural muscle triturated as above. ♀ ♀ *M. atlanis* used. 2nd passage.

No. 1.

No. of days.....	1	2	3	4	5
No. of deaths.....		5	3		

No. 2.

No. of days.....	1	2	3	4	5
No. of deaths.....		4	4		

Last three dead in No. 1 and two dead from No. 2 examined. "Souche Cham" recovered. No other organisms found.

TABLE XVIII.

Ten animals infected by spraying corn leaves with 24-hour bouillon culture of "Souche Cham." Five ♂ ♂ and five ♀ ♀ *M. atlanis* used.

No. of days.....	1	2	3	4	5	6
No. of deaths.....		4	1	4	1	

Three of dead animals "tested." "Souche Cham" recovered from feces and from alimentary tract. Two other organisms recovered.

TABLE XIX.

Eight animals infected by spraying corn leaves with 24-hour bouillon culture of "Souche Cham." Four ♂ ♂ and four ♀ ♀ *M. atlanis* used.

No. of days.....	1	2	3	4
No. of deaths.....		2	6	

Three animals "tested." "Souche Cham" recovered from alimentary tract. One other organism recovered.

*Signifies separate jars in which grasshoppers were kept, so really two separate experiments, otherwise I might have incorporated the two experiments in one table.

TABLE XX.

Nineteen animals infected by spraying corn leaves with 24-hour bouillon culture of "Souche Cham." *M. bivittatus* used. Proportion of sexes not noted.

No. of days.... 1	2	3	4	5	6	7	
No. of deaths..	3	2	2	2	4	3	Rest died of worm parasitism
	worm parasitism					worm parasitism	

Two dead on 3rd day "tested." "Souche Cham" recovered from alimentary tract. Other organisms recovered.

TABLE XXI.

Eight animals infected by spraying corn leaves with a 24-hour bouillon culture of "Souche Cham." Four ♂ ♂ and four ♀ ♀ *M. bivittatus* used.

No. of days..... 1	2	3	4	5	6	
No. of deaths.....			4	1	2	1 lived

One dead on 5th day "tested." "Souche Cham" recovered in pure culture from alimentary tract.

TABLE XXII.

Eight animals infected by spraying corn leaves with a 24-hour bouillon culture of "Souche Cham." Four ♂ ♂ and four ♀ ♀ *M. femur-rubrum* used.

No. of days.... 1	2	3	4	5	6	7
No. of deaths..			4	2	1	1

Two dead on 5th day "tested." "Souche Cham" recovered from alimentary tract. Other organisms recovered.

TABLE XXIII.

Ten animals injected with a 24-hour culture of "Souche Sidi." ♀ ♀ *M. atlanis* used.

No. of days.... 1	2	3	4	5	6	7
No. of deaths..	1	2	3	2	2	

Two animals dead on 5th day "tested." "Souche Sidi" recovered from blood in pure culture.

TABLE XXIV.

Ten animals infected by spraying corn leaves with a 24-hour culture of "Souche Sidi." Five ♂ ♂ and five ♀ ♀ *M. atlanis* used.

No. of days.... 1	2	3	4	5	6	7	
No. of deaths..	2	1	1	2	1	1	2 lived for 10 days and then died naturally after depositing eggs.
	worm parasitism						

Two dead animals "tested." "Souche Sidi" recovered from alimentary tract. Other organisms recovered.

TABLE XXV.

Eight animals infected by spraying corn leaves with a 24-hour bouillon culture of "Souche Sidi." *M. bivitattus* used. Sexes not noted, but majority females.

No. of days..... 1	2	3	4	5	
No. of deaths....		4	1	1	2 lived for about 10 days and then died after depositing eggs

One animal dead on 4th day "tested." "Souche Sidi" recovered from alimentary tract. Other organisms recovered.

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ADDITIONAL NOTES ON THE LIFE HISTORY OF BOMBUS AURICOMUS ROBT.

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During the summer of 1917 the writer was enabled to make some additional observations on the life-history of *Bombus auricomus* Robt., which resulted in the verification of several statements already published in a preceding article of his ('17), and in the addition of new facts of interest.

I. SPRING FLIGHT OF THE QUEENS.

The queens of *Bombus auricomus* in this vicinity began to fly in the spring of 1917 about the twelfth of May, and continued flying until about the first of July. The queen during the first few days of the spring flight flies rather near the ground, stopping now and then to sip the nectar from some attractive flower. Later this leisurely flight settles into an industrious search for a nesting site, the duration of the search depending entirely upon how soon the queen finds a favorable location. After a nesting site is once selected the queen busies herself mainly with collecting pollen in which to lay the eggs for her future brood.

From this time on, the flights of the queen from the nest gradually decrease in number, until at last there comes a time when sufficient workers have been produced to supply the necessary pollen and honey, and the queen seldom if ever leaves the nest. It is safe to say that nearly all the queens of this species in this vicinity in a normal season have started their nests by the first or second week in June.

II. METHODS USED IN STARTING A COLONY BY CONFINING THE QUEENS.

For several years I have tried confining bumblebee queens in separate artificial nests and feeding them, in the hope of getting the queens to start colonies, but this method has always failed. Sometimes a queen would seem to take an interest in the nest, pat the grass down about the pollen lump, and get very excited when disturbed, but always finally abandoned the nest. This season, however, I decided to try the placing of

two queens of the same species in the same nest, as Sladen ('12) did with the common European bumblebee, *Bombus terrestris* Linn.

On May 14, 1917, I caught one queen of *Bombus auricomus*, which I brought home and confined in an artificial nest. Another queen of the same species was caught a day later, and introduced into the same nest with the first queen. The wings of the latter queen were slightly notched before she was introduced into the nest, in order that I might distinguish her from the queen first introduced. The artificial nest used consisted of a small wooden box with a glass-sectioned top. In the box proper I had placed an old field-mouse nest, in which was a honey-moistened lump of honey-bee pollen. New pollen-lumps had to be placed in the nest from time to time, for the pollen when not worked by the queen soon dried out and became unfit for use. On June 13 a wax-pollen honey-cell was also placed in the nest near the pollen-lump. Liquid food, consisting of a mixture of common honey, rye-flour and water, was supplied to the bumblebees in a small tin container in a far corner of the box. Bright light was excluded from the nest by covering the top of the box with a sheet of dark red glass.

A. THE START OF A COLONY.

Though not showing any interest in the nest, both queens were producing considerable quantities of wax by May 27. This wax was scraped off and carelessly allowed to drop to the floor of the box. On June 13 almost a month since the queens were first confined, both queens suddenly seemed to take an interest in starting a colony. This interest was first manifested by their resting mostly on the pollen-lump, occasionally nibbling at the pollen, and buzzing excitedly when disturbed. For the next few days after this the queens were less active. On June 23, however, they showed renewed vigor, making during the night a honey-pot out of the accumulated and introduced wax, and also an egg-cell in the pollen-lump.

After this second start the activities of the two queens never abated. On June 24 one egg was found in the cell made on June 23, and two more empty cells had been constructed. On June 26 the two cells made on June 24 were closed over and each contained a single egg. Up to this time neither of the

two queens had ever seemed to mind the presence of the other, but from now on whenever the nest was disturbed, they often threatened each other without, however, ever engaging in actual combat. On July 2 larvæ were observed in the pollen-mass. They had probably emerged some days before, but as I did not care to disturb the queens, I had not examined these first few cells critically. It may be mentioned here that both the queens were still occupied with the nest, though the queen that was last introduced seemed to dominate the nest.

By July 10 the nest had progressed so far that I could remove the queens and photograph the nest, without the risk of causing the queens to abandon it. Here I may say that I believe it was the queen with the clipped wings that was the actual mother of the developing colony. As time progressed this latter queen more and more asserted her right over the colony, the other queen remaining listlessly about the honey-pot. Moreover, it seems hardly probable that a queen should start a colony and then calmly submit to its being monopolized by another, when queens under natural conditions usually fight over the nests. Again, from the beginning of the colony, the queen with the clipped wings had been the dominating figure.

On July 14 the larvæ began spinning their cocoons, more eggs were laid by the queen, and the nest promised well for the future. Frequently the queen could be heard making a purring noise, while brooding over the comb. On July 20 the first worker emerged, and by July 25 five more workers had made their appearance. The variation in the rate of emergence of these first few workers was mainly due to the egg-laying habits of the queen.

Of the later life-history of this colony little need be said. It may be mentioned, however, that later in the season the queen was accidently killed and the colony rapidly declined. The egg-laying habits, nest manipulations, wax-production, and other miscellaneous features were the same in this colony as described in my first article of this species ('17); with one exception.

The honey-pots in this nest, except for the one first constructed, were not so large nor were they so distinctly separated from the comb.

B. GENERAL FACTS OF INTEREST.

Prior to August 1, when the first queen was removed from the nest, neither queen had come to grief through the jealousy of the other. Sladen in his book on the "Humblebee" says that one of the queens, if two shared the same nest, killed the other about the time the first eggs were laid. Again, in this colony started with two queens, the first larvæ were reared to maturity without the addition of introduced workers.

III. Opening of a Field Nest of *Bombus auricomus*.

On September 6, 1917, Dr. J. W. Folsom and myself opened and removed a nest of *Bombus auricomus* of natural origin. This nest was found in a hollow cement block, the block being a part of the foundation of a small cabin. In order to remove the block and thus get the nest it was necessary to raise one corner of the cabin with automobile jacks. Upon removing the block we found that the bumblebee nest had been started in a mouse nest within the block. The bumblebees were very docile when the nest was removed, for instead of flying angrily from the nest, the most they did was to run excitedly about on the comb and buzz loudly.

A better protected or situated nest could hardly have been selected by a queen. An examination of this nest was valuable in that it afforded a comparison between a nest of natural origin and one established under more or less controlled conditions. Again, as this nest was taken in fall it was representative of the natural "climax" nest of this species.

A. NEST CONTENTS.

There were ten workers, three new queens and three males alive in the nest at the time of opening. Five dead workers were found in the debris of the nest. A careful search was made for the old queen, but no trace of her could be found. In addition to the above, several bumblebees which were not in the nest when it was opened, returned later and remained about the old nesting site for many days. No trace of the original wax-pollen honey-pot was found, or in fact any wax-pollen cells, except the egg cells. In two of the five dead

bumble-bee workers, I found the puparia of *Zodion obliquefasciatum* Macq. (Malloch det.). The nest was also infested by the phycitid moth, *Vitulas edmansii* Pack., which has been previously reported from the nest of *Bombus perplexus* Cress. by Franklin ('13).

B. LATER HISTORY OF THE COLONY.

After the removal of the nest to an observation box, one or more males emerged almost every day for two weeks, but no additional queens or workers. The males would stay in the nest for several days and then leave, perhaps returning and perhaps not. An attempt was made to secure the fertilization of the three queens by confining them with the males, but this failed. On October 9, two workers were still alive in the nest, but could scarcely move about. On October 12, these two workers succumbed to the increasing cold nights and the colony came to an end.

IV. SUMMARY OF THE LIFE HISTORY.

The following summary of the important facts in the life history of *Bombus auricomus* is based upon a study of the two colonies in this paper, and also upon my previous account ('17).

1. The nests are usually established in this vicinity sometime between the middle of May and the middle of June.

2. The bumblebees of this species are of a docile disposition as compared with such a species as *Bombus pennsylvanicus* De Geer.

3. The colonies are of rather small size.

4. The workers sometimes lay eggs, which are capable of hatching.

5. The eggs are laid in separate cells, several of which may be adjoining, but the cell-individuality is never lost.

6. The larvæ continue to remain isolated from other individuals in the same stage of development.

7. The life-cycle varies in individual cases, but may be said to last for all sexes about three and one-half weeks.

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EXPLANATION OF PLATE III.

Fig. 1. Side view of a nest of *Bombus auricomus* Robt., of natural origin, on September 8, 1917, showing: *a*, perpendicular arrangement of the comb; *b*, usual wax-pollen covering used in forming a protective envelope about the comb. Reduced.

Fig. 2. Top view of a nest of *Bombus auricomus* Robt., of natural origin, on September 8, 1917, showing: *a*, cocoon partially filled with pollen; *b*, cocoon used for storage of honey; *c*, three egg-cells; *d*, uncapped cocoons. Reduced.

Theo. H. Frison.

CONTRIBUTIONS TO A KNOWLEDGE OF THE CRAMBINÆ OF NORTH AMERICA. I.*

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Since undertaking a study of the Pyralid subfamily Crambinæ it has been found that the little that has been published concerning it is so widely scattered and so fragmentary that it is very difficult of access. In the present series of papers the writer proposes to bring together all the available information concerning each species, both that previously published and that which has resulted from his own work. Both systematic and biological data will be included when available but the papers cannot be exhaustive for our knowledge of many points is too scanty. They are designed to afford a convenient starting point for further work by making it unnecessary for others to go repeatedly over this same ground and to put within reach of economic workers the available facts which may be useful in economic studies of these insects. The bibliographies are intended to be complete and the writer will welcome corrections and additions thereto.

Crambus hemiochrellus Zeller.

SYSTEMATIC HISTORY. Aside from descriptions of the adult little has been published concerning this species. It was originally described by Zeller (1877). Grote (1880) listed it among the American species of the genus *Crambus*. It was reduced to a variety of *mutabilis* by Smith (1891) in which error he was followed by Felt (1894). Hampson (1895) placed it as a synonym of *luteolellus* but Fernald (1896) redescribed and re-established the species as valid and it so appears in Dyar's (1902) catalog.

DISTRIBUTION. Zeller's specimens, all of which were sent him from this country, were collected in Dallas and Bosque Counties, Texas. These are the only localities appearing in the published records. To them the writer can add Chattanooga, Tenn., Wellington, Kan., and Elk Point, S. D., moths having been taken at the first two places by himself and at the last

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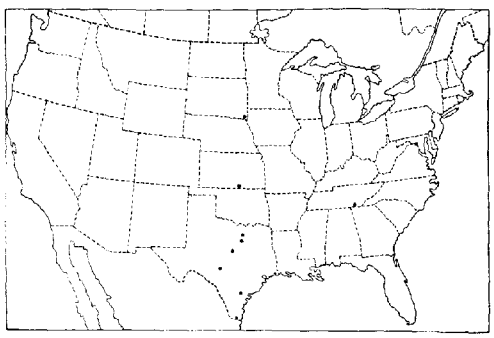
by Mr. C. N. Ainslie. The nineteen specimens in the collection of the U. S. National Museum bear locality labels from Devil's River, Dallas, Victoria, Sabinal, Kerrville, Plano and Brownsville, Texas, one simply "Ariz." and one taken at light at Washington, D. C. From these scattered data no definite limits for the distribution of the species can be fixed but in spite of its comparative rarity it appears to be widely diffused. The map below shows the location of the above mentioned localities.



Map of the United States showing points at which *Crambus hemiochrellus* has been collected.

FOOD PLANTS. Nothing is known of the normal food plants. Larvæ were easily reared to maturity on bluegrass (*Poa pratensis*) and doubtless would have accepted any one of a large number of grasses in common with other species of the genus.

SEASONAL HISTORY. Zeller states that the moths fly in Texas during the last half of May. The first moths seen by the writer were those taken at Chattanooga on June 11. Others were taken at Wellington, June 27, and at Elk Point, July 19. All of these were captured alive and sent at once to the Bureau Field Laboratory at Nashville, Tenn., where eggs were obtained and larvæ reared from each lot. The larvæ from the Chattanooga moths pupated as soon as mature and adults emerged on August 5, 7, 11, 14 and 15. Part of the larvæ from the Kansas moths pupated as they reached maturity and moths emerged August 23, 26, 30, and September 2 and 13. The rest of the larvæ in this series did not pupate but continued slowly

to feed until they were supplied with damp sand in which they at once constructed retreats. They lay dormant in these retreats for weeks and the last of them died the following January without further change. The larvæ resulting from the South Dakota moth showed this same habit though in a more pronounced degree for none of them pupated in the fall and all died during the winter. If these overwintering larvæ could have been kept under exactly suitable conditions they would without much doubt have pupated in the spring and formed the first generation of moths. Attempts were made to breed the moths which emerged in the cages but no fertile eggs were obtained.

A consideration of the foregoing data together with the dates of collection of the moths in the National Museum indicate that in the latitude of Tennessee and southward there are two complete generations each year, the moths of the first appearing during the first half of June and of the second about two months later, in August. The collection of other moths at Wellington, August 8 and 15, by Mr. C. L. Scott, lends further support to this hypothesis. Somewhat farther north there is a complete first and a partial second generation, some of the offspring of the first remaining as larvæ until the following spring. As far north as South Dakota it is likely that few if any of the larvæ resulting from moths of the first generation pupate the same year. It appears that even in Texas there are but two generations in a year as no moths are recorded from there later than July 22. It is possible, however, that there is a complete or partial third generation in which case further collections should show moths appearing there in September.

Habits of Moths. Of the habits of the moths little is known. Those taken at Chattanooga were flying in a dry grassy field in company with *C. caliginosellus* which they so closely resembled in manner of flight and general coloration that the presence of two species was not suspected until they were examined later. At Wellington the moths, perfect unrubbed specimens, were attracted to a light trap. Eight of the nineteen specimens in the National Museum were taken at light. It is an indication of the scarcity of the species that with its positive phototropic tendencies so strongly marked it is not more commonly met with in collections.

EGG LAYING HABITS. The three captured females of which records were kept laid respectively 147, 184 and 303 eggs in confinement. A number of the reared moths of both sexes were confined together but eggs, 92 in number, were obtained from but one female and they were infertile.

REARING METHODS. Larvæ were found to be comparatively easy to rear. Four series were reared from the egg and adults were obtained in three of them. The larvæ were confined in half-ounce tin salve boxes floored with damp blotter to keep the food fresh and absorb excess moisture. They were examined daily, fed, and the boxes cleaned as often as necessary. They were fed only on bluegrass cut in short lengths. Larvæ in each instar were described and preserved. In one series a record was kept of the amount of food consumed. The data given in the rest of this paper are derived from these rearings and while perhaps varying somewhat from actual field conditions give at least a basis for comparison with other species reared by similar methods.

STAGE AND INSTAR RECORDS. The duration of the egg stage is variable, being directly dependent on temperature. The length of the first instar is also variable for some larvæ began at once to feed while others remained inactive for two or three days. Up to the seventh instar the rate of growth is very consistent. Here a complication arises for the instar immediately preceding the change to the pupa is always the longest whether it be VII, VIII or IX. Three larvæ which pupated from VII passed 13 days each in that instar while 15 larvæ which molted to VIII averaged but 4 days in VII. This explains the sudden increase in the maximum length of the seventh and succeeding instars in Table I in which are condensed the data secured as to length of instars and stages.

TABLE I.

LENGTH IN DAYS OF INSTARS AND STAGES.

Stage	Maximum	Minimum	Average	Number Averaged
Egg	9	8	9	..
Larva	47	39	43.6	9
Instar I	8	2	5.09	121
II	5	2	3.33	107
III	5	2	3.25	87
IV	7	2	3.64	79
V	9	2	4.62	67
VI	7	2	4.23	58
VII	17	2	5.18	50
VIII	14	3	7.66	41
IX	22	4	10.60	16
X	8	8	8	1
Pupa	14	9	10.40	10

The normal number of instars for the larvæ of this species is probably seven for the males and eight for the females, though some individuals in each of the reared series exceeded this number. One even reached the twelfth instar. Table II gives the larval measurements for the various instars.

TABLE II.

LARVAL MEASUREMENTS IN MILLIMETERS.

Instar	Head Width		Average	Number Averaged	Body Length
	Maximum	Minimum			
I	.....	.....	.194	..	1.2
II	.....	.....	.264	..	2.0- 2.8
III	.424	.318	.362	16	3.0- 4.0
IV	.580	.440	.524	14	6.0
V	.880	.635	.750	16	8.0–10.0
VI	1.165	.724	.920	19	10.0–12.0
VII	1.483	1.130	1.318	11	15.0
VIII	1.726	1.119	1.586	21	20.0
IX	1.632	1.213	1.446	21	23.0
X	1.586	1.353	1.469	4	.....

Table III shows the sex and the instar at pupation of nine of the moths reared.

TABLE III.

Number moths reared	Last larval instar	Moths Emerging	
		Male	Female
2	VII	1	1
2	VIII	2	0
4	IX	2	2
1	X	0	1

During the first three instars the larvæ fed mostly by skeletonizing the leaf, leaving only the membrane on one side. Part of those in III and all from that time on consumed the entire leaf. The amount of food consumed progressed in a fairly definite ratio, the amount eaten in any instar being about 100% greater than that eaten in the preceding instar. In this respect a larva about to pupate behaved differently than one still growing for during the last instar its desire and capacity for food seemed almost insatiable until within two or three days of pupation when it ceased entirely to feed, contracted, became sluggish and prepared for the change. It is noteworthy that larvæ of this species did not eat the molted larval skins and head casts as do those of many species of *Crambus*. The larvæ in the series of which the food record was kept were given measured pieces of bluegrass leaves and at the end of each instar the uneaten portion was removed and measured. A skeletonized leaf was considered to be two-thirds consumed. Table IV shows the amounts of food consumed by the larvæ in each instar in linear millimeters of bluegrass leaves which average about 3 mm. in width.

TABLE IV.

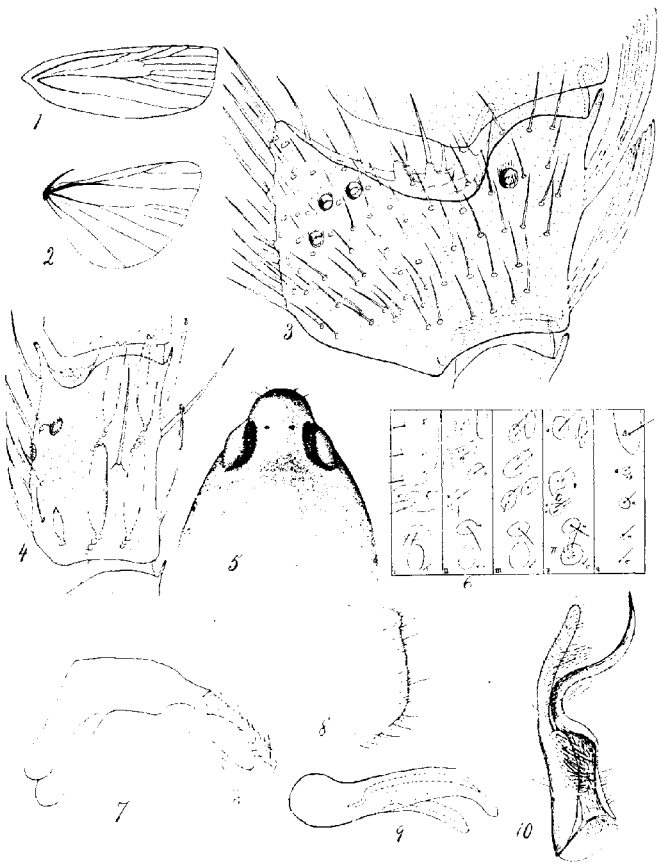
BLUEGRASS LEAVES IN LINEAR MILLIMETERS CONSUMED.

Instar	Maximum	Minimum	Average	Number larvae averaged
I	6	2	3	41
II	16	1	7	36
III	20	3	13.7	26
IV	33	5	19.4	25
V	82	19	45.5	23
VI	176	18	101	21
VII	1095	38	336	11
VIII	990	190	474	13
IX	1370	180	832	6
X	420	420	420	1

SYSTEMATIC POSITION. In its relationships this species lies between *C. trisectus* and *C. mutabilis*, more closely allied to the latter. The moth resembles that of *mutabilis* in the dark shading on the costa proximad, the dentate subterminal line and the whitish veins in the middle of the forewing. It is, however, more richly colored than that species and especially do the yellow stripes in the posterior half of the primaries contrast with the much less lively coloration of *mutabilis*. Structurally its close approach to *mutabilis* is shown in the narrow forewing, the broadly pectinate male antennæ, the naked spine-like harpe (Fig. 10) and the hooked uncus (Fig. 6). It differs in that the male antennal processes (Fig. 3) are less abundantly supplied with sensoria, the scaphium is longer, the valve is both longer and somewhat wider and the harpe while spine-like is large, doubly curved and long, exceeding the valve. This latter character in itself is sufficient to define the species for in *mutabilis* the harpe is a slender spine not more than half the length of the valve and in *trisectus*, the nearest form on the other side, the harpe is falcate and setigerous and in length about equals the valve. The relationship to *mutabilis* is shown also by the larvæ for the markings of the two are very similar differing only in shade, brick-red for *hemiochrellus* and dull brown for *mutabilis*. During their incubation period the eggs of the two species assume very nearly the same shade, a pale salmon-yellow.

DESCRIPTIONS. Adult: The description of the adult moth as given by Fernald (1896) is very accurate and complete and is here quoted with the addition of a description of the genitalia by the writer.

Expanse of wings, 22 mm. Head and thorax pale ochre-yellow; palpi thickly sprinkled with grey atoms. Fore wings bright ochre-yellow between the white median vein and hind margin with dusty stripes, and usually with a clear yellow stripe along the fold; costal portion yellowish-gray, darker toward the base; median line fine, rust-brown, forming an acute angle at the end of the cell, and extending in a nearly straight line to the middle of the hind margin; subterminal line fine, dark brown, dentate on the veins and parallel with the outer margin except at the costal end, where it curves sharply inward and terminates at the outer fourth of the costa; terminal space dusty-gray; terminal line rather indistinct, upon which in some specimens, may be seen seven very fine dark gray dots; fringes light gray. Hind wings light gray; fringes lighter.



EXPLANATION OF FIGURES.

Fig. 1. Venation of fore wing.
Fig. 2. Venation of hind wing.
Fig. 3. Antenna, male, 25th segment.
Fig. 4. Antenna, female, 25th segment.
Fig. 5. Tip of pupa, dorsal view.
Fig. 6. Setal map showing arrangement of pinacula and setae on three thoracic segments and the 3rd and 9th abdominal.
Fig. 7. Male genitalia, scaphium, uncus and lower limb.
Fig. 8. Female genitalia, edge of anal plate.
Fig. 9. Male genitalia, penis.
Fig. 10. Male genitalia, clasp showing harpe and valve.

Genitalia. Female—Anal valve (Fig 8) broad, nearly square in outline, not constricted at the base, dorsal angle rounded and slightly produced. Male—All parts uniformly and moderately chitinized; body of scaphium (Fig. 6) narrow, slightly longer than the limbs, which are narrow and rounded distad; uncus slender, elongate, slightly enlarged distad and ending in a small but distinct sharp hook, hirsute above, lower limb very slender, exceeding the uncus, its branches very short, naked; clasps (Fig. 10) strongly concave at the base, valve slender, elongate, uniformly clothed on the inner surface with fine hair and at its base a heavily spined, rounded lobe; harpe a long, strong, S-shaped, naked spine, exceeding the valve; penis (Fig. 9) moderately chitinized, bulbous at base and tapering to an obliquely truncate, curved tip, hollow, open at the end, with a slender, chitinous internal spine more than half the length of the organ extending nearly to the tip, the whole organ subtended by a weakly chitinized plate attached about the middle.

Our specimens agree exactly with the descriptions of Zeller and Fernald except that in some individuals the terminal line is somewhat more distinct than they indicate and the forewings of our specimens do not have the acute apex with the slight curve beneath that Zeller mentions.

The larva, especially in the later instars is easily distinguished from other Crambin larvæ we have seen by its color, a bright brick-red arranged in longitudinal stripes separated by irregular broken white lines. The head, black in the newly hatched larva, becomes in the larger instars a clear pale yellow, in some individuals faintly clouded with darker yellow. Technical descriptions of the egg, larval and pupal stages follow. Terms as defined and used by Fracker for the larva and Miss Mosher for the pupa are used. Larval measurements are condensed in Table II and are therefore omitted from the descriptions.

Egg. Elongate oval, bluntly rounded at both ends one of which is slightly smaller than the other; chorion with 17 acute longitudinal ribs, 5 or 6 of them running to the pole at each end, the others appearing as the interspaces widen; interspaces faintly transversely striate throughout their length. Measurements (10 eggs):

Length, maximum .529 mm., minimum .460 mm., average .496 mm.
Width, maximum .318 mm., minimum .300 mm., average .307 mm.

The eggs are pure white when laid, when a few hours assume a yellowish tinge and at the end of three or four days become pale salmon-yellow, remaining thus until about twenty-four

hours before hatching, when the black head and dark cervical plate show as a spot and transverse band close to one end of the egg. The hole through which the larva emerges is made at one side of the larger end of the egg, its edge usually just reaching the pole. The empty shell is transparent and iridescent.

Larva. Instar I.—Head black, cervical plate deep fuscous to black; body when first hatched clear pale yellow with minute pinacula, which later become dingy and more conspicuous.

Instar II.—Head uniformly fuscous, mouth-parts paler, ocellar area and latero-caudal margin of head black; Cervical plate fuscous, a little paler than head. Pinacula on meso- and meta-thorax small, dusky, those on abdomen larger and more conspicuous because of a shaded pigmented area just cephalad of each. Abdomen tinged with brick-red and already showing faintly the striped pattern of the larger larvæ.

Instar III.—Head uniformly clear brownish-yellow, cervical plate concolorous with head or a little paler. Pinacula dusky and conspicuous, larger and more deeply pigmented caudad. Spiracles small, dark, not prominent in all specimens.

Instar IV.—Head clear pale yellow without markings except the black ocellar area and latero-caudal margin; mouthparts outlined and the facial sutures marked by very fine dark lines. Cervical plate pale fuscous, darker than head. Pinacula on thorax and abdomen large, mostly surrounded by shaded pigmented areas which make them appear larger. Body plainly longitudinally striped with red, the stripes running one between the dorsal line and alpha and the other between beta and rho on each side, four main stripes separated by narrow whitish more or less broken and irregular lines.

Instar V.– Head uniform clear pale yellow, mouthparts outlined with fine dark lines, ocellar area crescent-shaped, black. On the margin of head caudad of ocellar area is a small black spot from which a heavy dark line runs dorsad margining the head to the vertical triangle. Cervical plate large, pale yellow, darkening laterad and with a small dark spot in the center of each lateral extremity. Spiracles small black, nearly round and with a black cicatrix of the same size but more elongate, caudad and a little dorsad on each of the pedal segments.

Instar VI.—Head clear pale yellow, some faintly clouded with darker yellow, ocellar area black, crescent-shaped, caudal margin of head black beginning at a small black spot caudad of ocellar area. Cervical plate broad, pale, slightly darker than head, with paler median stripe and a faintly dusky spot near the lateral margin.

Instar VII.—Head clear pale yellow, occasionally slightly clouded with darker yellow, black latero-caudal marginal line distinct but becoming faint toward vertical triangle. Facial sutures indistinct, mandibles dark, ocellar area reduced in size, the two terminal ocelli

isolated. Cervical plate large, concolorous with head or somewhat paler, with a pair of medio-lateral spots and dark prominent setæ; cicatrices on pedal segments prominent, black, of the same size as the spiracles.

Instar VIII.—Head clear pale yellow, faintly clouded with dark, ocellar area black, caudal margin of head black beginning at a black spot on margin of genæ; setæ on face pale brown, arising from minute clear, brown-edged circles. Cervical plate large, pale, concolorous with head or paler, with small brownish spot near lateral extremity and a group of dots on each side of median line near caudal margin, median line pale. Kappa almost directly dorsad of eta on the abdominal segments. In live specimens the pinacula have their outlines obscured by the reddish stripes which cross them. These stripes appear first in II and III and become more pronounced until in the older larvæ they give the color to the whole body. They run as follows: a narrow medio-dorsal line, a wider one on each side of this and separated from it by a narrow broken whitish stripe runs through the outer half of pinacula alpha and includes beta, between this and rho runs another white line similar to that dorsad of alpha below which the spots and body are various shades of suffused red, pink and salmon. The larva as a whole appears of a bright brick-red color. In alcohol the red striping disappears.

Pupa (Fig. 5)—Length 9 mm., width 2.7 mm. Of the usual pyralid shape, yellowish brown, the sutures marked by narrow maroon lines. Epicranial suture obsolete; fronto-clypeal suture present only at margin, running a short distance meso-ventrad from the ventral corner of the antennæ; front with a large, dark, flattened and somewhat depressed tubercle mesad on ventral margin and a small dark point mesad near caudal margin of clypeus; maxillæ almost equaling wings; tarsi of prothoracic legs ending about two-thirds of the distance from vertex to caudal margin of wings; antennæ extending about half way from the tips of the mesothoracic tarsi to the caudal margin of the wings; prothorax large, strongly convex cephalad, caudal margin straight and only slightly elevated and wrinkled laterad for the prothoracic spiracles; mesothoracic wings extending to caudal margin of fourth abdominal segment; cremaster short blunt, rounded or feebly angled distad, above sloping with two minute attenuate spines at the angles and with a short deep curved furrow on each side running from the base cephalad, laterad and ventrad finally becoming obsolete on the lateral line, beneath excavated and flattened, the distal angles each bearing a spine like those above, but smaller and closer together.

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SEASONAL AND CLIMATIC VARIATION IN CERODONTA.

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Cerodonta dorsalis is a small fly of the family Agromyzidæ (sens. str.), the larva of which mines in the leaves and leaf-sheaths of wheat, timothy, etc. It is very widespread in the United States and Canada.

It was described by Loew (a) in 1863, the type being a female from the District of Columbia. He referred it to the genus Odontocera Macquart (b), a preoccupied name, for which Rondani (c) had proposed to substitute Cerodonta, and a year later Schiner (d) had proposed Ceratomyza.

In September, 1913, Melander (e) restored Rondani's overlooked generic name‡ and separated his North American material into two species on color characters; one he called *dorsalis* Loew, represented from Massachusetts, Louisiana, Illinois, and Texas; the other he identified with the European species *femoralis* Meigen, represented from Montana, Wyoming, Idaho, Washington, British Columbia, Oregon, and California. The latter species he compared with European specimens determined by Strobl.

A few days later, about Oct. 1, 1913, Malloch (f) published his large revision of Agromyza and also took up this genus Cerodonta (he used the original but evidently erroneous spelling Cerodontha). He recognized but one North American species, *dorsalis*, not considering the variations in color to be of specific importance. The National Museum material, with which he was working, was from eighteen States, Atlantic and Pacific among them, and also from Mexico and Porto Rico. Neither Melander nor Malloch knew until about the time of publication that the other was working upon the group, and the two conclusions were arrived at independently.

When I began in 1913 to do some biological work on the group, the difference of opinion between two prominent dipterists as to the species limits presented itself as a problem to

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‡Mr. Mallock has called my attention to an earlier use of Ceradonta by Collin, Ent. Mo. Mag., Nov. 1911, p. 254.

be solved. I found I had about fifty specimens from the Rocky Mountains and points west of them, all of general dark color and agreeing with *femoralis* as identified by Melander; I also had about an equal number from localities east of the Rockies, all of paler color and undoubted *dorsalis*. This led me to conclude provisionally that Malloch had not given sufficient weight to the geographical segregation of the two forms, and that they were probably distinct species.

The color difference is most conspicuous in the pleuræ, which are almost wholly yellow in eastern material, and blackish with paler sutures in the western; the dorsum, tibiæ, frontal orbits, etc., share in varying degrees in the lighter or darker coloration.

My observations in Indiana in 1914 seemed to confirm my opinion that the western dark form is a distinct species, as I found no such coloration in Indiana specimens, of which I examined a large number.

In 1915 I began to make systematic sweepings on grass and grain and tabulate the flies collected. In this I secured the assistance of several entomologists who swept for me in regions that I could not personally visit.* This brought into my hands a large amount of material in Cerodonta (1876 specimens in the season). During most of the season these ran as expected, dark from the Rockies westward, pale from east of that region. Sweepings from Fort Collins, Colo., August 17, showed for the first time in my experience light and dark forms intermingled; but this place is just on the dividing line, where overlapping might be expected. Sweepings from Great Falls., Mont., September 23, showed the dark form some distance east of the mountains for the first time. On October 9th it turn up at Treesbank, Man., where I had had the pale form earlier in the season. On October 19th dark and intermediate forms were swept at Elk Point, S. D., where light specimens had been abundant earlier; and by this time I was noticing that specimens swept at Lafayette were becoming progressively darker. I continued my sweepings here as late as possible, and on Nov. 27th secured two specimens as dark as any from the west. Specimens from Atherton, Mo., Nov. 6th, were in part

*I wish especially to acknowledge important and continued co-operation from Messrs. Norman Criddle, Treesbank, Man.; C. N. Ainslie, then at Elk Point, S. D.; and Dr. C. F. Adams, Atherton, Mo.

dark also. So it seemed completely demonstrated that in late fall the eastern specimens may become as dark as the western—undoubted lineal descendants of the pale midsummer broods, among which dark forms never occur.

In the summer of 1916 I continued sweeping more actively than before, but not very late in the fall. The only additional observations of any significance on this matter were the collection of one somewhat dark specimen at Aberdeen, S. D., on May 29th, and of several dark ones mixed with a much larger number of light ones at Sioux City, Ia., on May 23d and 26th (Ainslie). This showed that the first spring brood is also affected by the tendency of cold to produce dark colors. The total number of specimens examined in the season was 513, although the number of sweepings was much larger than in the preceding year, indicating that the species was much less abundant in 1916. Except as noted already, all Indiana specimens were decidedly of the pale form, except a single one taken May 10, 1915, which was intermediate.

In 1916 I received from T. D. Urbahns, then located at Pasadena, two pale specimens taken at Yuma, Ariz., which were the first of this form that I had ever seen from the region in or beyond the Rockies.

In the summer of 1917 I was enabled to extend my observations into the Southwest in June, making stops for collection at Marfa, Texas; Las Cruces, N. M.; Tucson, Tempe and Yuma, Ariz. Sweepings at all of these places gave the pale form only, and the prevailing tempertaure seemed an ample explanation of the phenomenon. Continuing my trip, I collected at San Diego, Cal., in late June, and in July at Santa Barbara, Berkeley, Palo Alto, Martinez, and Fallen Leaf, in California; in Utah at Salt Lake City and in Emigration Canyon at an elevation of 7000 feet; and in Colorado at Tennessee Pass, elevation 10,290 feet. At all of these places I collected only the dark form, and it was abundant wherever fresh grass occurred.

Evidently *dorsalis* is no more than a pale variety of *femoralis;* but when we turn to the European literature we find a whole series of names that have been proposed on color characters that are mostly the same as the ones just discussed in our species. Hence there is some doubt as to whether *femoralis* is not itself a variety of *denticornis*, an older name; and also as to

whether *dorsalis* is not antedated by a European name for the same form. These questions will evidently have to be left to European dipterists.

The color variations described fall in the same class as a number that have been studied in Lepidoptera (for instance see a series of articles by Standfuss in The Entomologist, XXVIII, 1895, and a translation of Weismann's experiments in the same journal the following year by W. E. Nicholson), in which low temperature during the pupal period causes the colors to be darker. This may normally affect one brood of a double-brooded species, or it may be climatic rather than seasonal, affecting all the individuals living in the colder region. Even the absence of the pale form of Cerodonta in the west in mid-summer accords with butterfly experiments, in which the pale form can be made dark by cold, but the dark form cannot be made pale by heat, indicating that the dark is the primitive type, the pale a comparatively recent modification.

While the subject has not been systematically studied except in Lepidoptera, some observations in other orders agree well; for instance, Horn (g) says of the Clerid beetle *Trichodes ornatus*. "As a rule, the hotter the climate in which the specimens were native, the greater the extent of the yellow color. . . . In colder, and especially damper climates, the blue color predominates."

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LIFE-HISTORY OF THE LEAF-EATING CRANE-FLY.
Cylindrotoma splendens, Doane.

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CONTENTS.

INTRODUCTION.

On April 28, 1917, whilst on a journey undertaken with a view to determining the distribution of the Pear Thrips, *Taeniothrips inconsequens* Uzel on Vancouver Island, the author had the good fortune to discover a curious, Tipulid larva quite unknown to him. The locality of the discovery was in the rural district of Westholme about 40 miles north of the town of Victoria. His attention was first drawn to the insect by his co-worker, Mr. E. W. White, Assistant Horticulturist of the Department of Agriculture, British Columbia, whose interest was first aroused by the feeding activities of the larva. In a rich woodland timbered by lofty cedars and spreading, large-leaved maples, there was growing in great luxuriance the false bugbane, *Trautvetteria grandis*, which affects damp and well-shaded habitats. It was on the leaves of this perennial, ranunculaceous herb that the larvæ in question were feeding in large numbers, eating out large, irregular holes. The insect was successfully reared, and the adults submitted to Mr. Chas. P. Alexander, Department of Entomology, Cornell University, who identified the species as *Cylindrotoma splendens*, Doane, in a letter dated May 25, 1917. In reply to a letter of the author, in which the finding of the larvæ was mentioned and their general appearance outlined, Mr. J. R. Malloch, of the Illinois State Laboratory of Natural History, Urbana, Illinois, under

date of May 20, 1917, suggested with admirable foresight, that the species perhaps belonged to the tribe *Cylindrotomini* of the Tipulidæ; but, as material had not then been forwarded to him, he could not naturally diagnose the species from a brief, written description. Later, however, he was able to corroborate Mr. Alexander's determination from specimens sent from the writer's collection.

Fig. 1. Larvae of C. splendens feeding on a leaf of their food plant (*Trautvetteria grandis*. About natural size. (Original.)

The intrinsic value of the discovery lies in the fact that, according to Mr. Alexander, this represents the first finding of the immature stages of any species of the genus *Cylindrotoma* on the American continent, and it is hoped that the publication of this paper will stimulate other entomologists to search for these very interesting larvæ. A study of their habits will well repay one's efforts by reason of their decided contrast to those of the generality of Tipulid larvæ.

PRESENT KNOWLEDGE OF THE CYLINDROTOMINI.

The literature dealing with this very interesting tribe of the Tipulidæ has not been accessible to me, with the exception of Mr. Alexander's paper, "Biology of the North American Crane-Flies (Tipulidæ Diptera)," published in the Pomona College Journal of Entomology and Zoology, Vol. VI, No. 3, Sept., 1914. Here is presented excellent résumé of the known facts, culled from various workers, regarding this very remarkable group of species, which, according to Osten Sacken, quoted by the author (p. 105), occupies an isolated and intermediate position between the *Tipulidæ brevipalpi* and *longipalpi*. Mr. Alexander goes on to say that "the structure of the adult flies, especially as regards certain details of the venation of the wings, is quite unique, but it is in the immature stages of the different genera that the most interesting distinctions are found. The larvæ, instead of living in the mud along the banks of streams, or in rotten wood, as do the majority of the known crane-fly larvæ, are found on the leaves of various terrestrial and aquatic plants; instead of being brown or grey in color, they are bright green and usually resemble the leaves of their host plants to a very remarkable degree.

The five known larvæ of the *Cylindrotomini* are distributed among four genera as follows: *Phalacrocera replicata*, L., which is aquatic or nearly so and feeds on *Fontinalis antipyretica*, *Hypnum elodes*, *H. exannulatum*, *Ranunculus fluitans*, etc.; *Cylindrotoma distinctissima*, Meig., terrestrial, feeds on *Viola biflora*, *Stellaria nemoralis*, *Anemone nemorosa*, etc.; *Triogma trisulcata*, Schumm., aquatic, on *Fontinalis antipyretica*; *Liogma glabrata* Meig., terrestrial, on *Hypnum squarrosum; Liogma nodicornis* O. S., terrestrial, on *Hypnum cupressiforme* and a related species. All with the exception of the Neartic *Liogma nodicornis* are Paleartic. For the larvæ of these five species Mr. Alexander (*loc. cit.*, pp. 109–110,) has constructed a key wherein the distinguishing characters are the shape of the body-appendages and the number and position of the teeth on these appendages. He proceeds to state that "the larvæ of the Cylindrotomini may be distinguished from those of other crane-flies by the following easily determined points: color green or greenish; the body provided with filiform or leaf-like appendages; larvæ living upon various Bryophytic or Spermatophytic plants."

LIFE-HISTORY AND HABITS.

The adults first appear on the wing about the middle of May, the first specimen in the rearing-boxes emerging from the pupal skin on May 15, the great majority appearing on May 21 and 24. Without food, they do not live longer than five to six days, but in the breeding-cages when they were supplied with food in the shape of sugar solution, they lived as long as 7 to 9 days. In the field, the adults were found on the wing for a period extending over three weeks, May 17–June 7. Soon after emergence the adults begin to copulate, and one male may perform the act of coition with more than one female.

Copulation.—The first individuals were observed to be copulating in the rearing boxes on May 22. The act is undertaken by the sexes apposing their abdomens end to end, the claspers of the genitalia of both interlocking. The head of the female is oriented in the direction diametrically opposed to that of the male which remains suspended with his head towards the ground. When copulation occurs between individuals resting on a vertical surface, such as the walls of the rearing-box, the female is invariably superior in position to the male. In both cases the sexes have all their legs applied to the supporting surface. Sometimes copulation was observed to be taking place among individuals on the inside of the roof of the rearing-cage. Here, only the female at times would be resting on the roof with the male suspended head downwards, its body at an angle of 90° with that of the female and its legs unsupported. The act of copulation is not always interrupted when the sexes are disturbed, but the female may walk off dragging the male after her, or flight may be actually undertaken with the female transporting the male. Pairs in copula were frequently transferred from one rearing cage to another without the union being broken.

In the field, the behavior during copulation was similar to that observed among the sexes in the rearing-cages. Here the act was generally undertaken in the deep shade of the large leaves of the food-plant, *Trautvetteria grandis*, the sexes resting on the under-surfaces of the leaves, or on the stems. When disturbed, the females took to flight, bearing the males with them undisturbed.

No exact records were kept of the time that the sexes remain in copula. It varies considerably, however, and gen-

erally, copulation may continue for two or three hours and even longer. In some cases, the sexes remained in union only a matter of a few minutes.

Oviposition.—Eggs were first observed on the leaves of *Trautvetteria grandis* in the breeding-cages on May 25th when the first female was seen to oviposit. On the following day, a few eggs were found on the leaves in the field at Westholme and on a subsequent visit on May 31, were found to be very numerous.

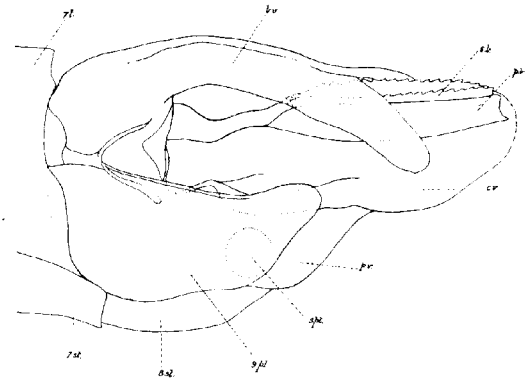


Fig. 1a. Ovipositor: *7 t.*, seventh tergite; *7 st.*, seventh sternite; *8 st.*, eighth sternite; *9 pl.*, ninth pleurite; *spt.*, spermatheca; *b. v.*, bifurcated valve; *p. v.*, ploughshare valve; *c. v.*, cutting valve bearing serrated blade (*s. b.*) and plain blade (*p. b.*). Camera lucida drawing. × 40.

In order to understand the behavior of the female *Cylindrotoma* in ovipositing, it is necessary that we should recapitulate in brief the structure of the ovipositor (See Figure 1a). It consists of a pair of large double-bladed valves (*c. v.*), each of which is sparsely clothed with rather elongated, delicate hairs and more closely invested with short ones. The inner blade (*s. b.*) in each case is serrated along its upper margin which is distinctly recurved externally. The serrations of the proximal half of the blade are directed anteriorly, those of the distal half being directed posteriorly. On each of these cutting valves, external to the saw-edged blade, is a plain blade (*p. b.*), the upper margin of which is slightly recurved externally and overtopped by the serrated margin of the inner blade. Both blades have their attachment in the dorsal half of the valve. Dorsal to

these cutting valves is an unpaired and unarmed valve, bifurcated in its posterior third (*b. v.*), the two arms of the bifurcation each straddling the cutting valves and being continued at rest beyond the insertion of the blades of these latter valves. It is sparsely invested with long, slender hairs, more thickly disposed on the two bifurcating arms. Along its dorsal median line there runs from the point of bifurcation a narrow depression which terminates at its base. Ventrally, and arising apparently from the eighth sternite and between the paired ninth pleurites, is a ploughshare-shaped valve (*p. v.*), strongly chitinised and invested laterally with short, coarse hairs. It terminates in a position between the cutting valves, the extremities of which extend beyond its apex. The two spermathecæ (*sp.*) are dark-brown, strongly chitinised spherical organs in the ninth segment. The spermatheca is tripartite in some Tipulidæ.

The eggs are sub-translucent glistening white, elongate-ovate in shape. Under natural conditions they are almost invariably to be found on the under surface of the leaves of the food-plant, *T. grandis*, inserted beneath the incised epiderm (Figure 7). They are generally deposited in series along the margin of the palmately-lobed, serrate-edged leaf, and just internal to the periphery. They may occur in groups of one or more, all arranged parallel to each other and with their long axes perpendicularl to the margin of the leaf, or at least, varying but slightly from the perpendicular. The eggs are only partly hidden beneath the incised epiderm. They are exposed dorsally, the margins of the slit made by the ovipositor overlapping the egg laterally, and to a small degree, both anteriorly and posteriorly. The arrangement of the eggs in series and their partial exposure, lends to the leaf-margin a somewhat beaded appearance. When newly laid, the eggs are not readily observed by the naked eye, unless one examines the leaves closely. Later, owing to a darkening of color of the eggs as well as of the leaf-margin which turns brown, they are more readily detected.

Not only are the eggs deposited along the leaf-margin, but often where a leaf has been eaten earlier in the season by the larva, one will find eggs deposited along the ragged edge of the damaged leaf.

In the breeding-cages, the females laid their eggs indiscriminately on both the upper and lower surfaces of the leaves, but in nature, no eggs were ever found on the upper surface.

The actual method of oviposition was frequently observed. The female rests on the under side of a leaf with the extremity of the abdomen directed towards the leaf-edge. The abdomen is slightly recurved vertically, and the margin of the leaf is grasped between the bifurcated valve of the ovipositor which is applied to the upper surface of the leaf, and the paired, cutting valves the blades of which are apposed to the under surface. These blades are then moved to and fro, and a slit is cut in the epiderm, the recurved margins of the blades serving to widen the aperture of the slit. The ploughshare, ventral valve then comes into play, serving to guide the emerging egg into its position in the slit. By reason of its being excavated internally, after the fashion of a deep-keeled boat, this valve performs its function admirably. The valves are then withdrawn, and the performance may be repeated alongside the first slit, a number of these finally producing the parallel-beaded arrangement of the eggs along the margin. In no instance do the eggs actually touch upon each other as one finds in the case of eggs laid in parallel series by the leaf-mining species of the *Pegomyia* genus of Anthomyiid diptera.*

Duration of Egg-stage.—The period of incubation occupies about two weeks. In the breeding-cages, eggs hatched in from fourteen to eighteen days, and it is not unlikely that under field conditions, the egg-stage endures for two to three weeks. Records show that under experimental conditions, the first eggs were deposited on May 22, and the date of first hatching was June 7. The first, newly-emerged larva was taken at Westholme on a leaf of *T. grandis* on May 31.

The Embryo and Emergence of Larva.—The maturing embryo is at first distinguishable within the egg by the appearance of two dull, red spots, one on each side of the anterior extremity of the egg. Presumably these indicate the position of the eyes. Later, as the embryo develops, the black head-capsule stands out quite markedly within the transparent chorion.

The actual time occupied by the larva in leaving the egg is about three hours. In its efforts to free itself, it is not at all energetic. In one particular case, on June 7, the young larva made slow movements from side to side, erecting its head and

*Cameron, A. E.—A Contribution to a Knowledge of the Belladonna Leaf-Miner, *Pegomyia hyoscyami*, Panz. its Life-History and Biology. Ann. App. Bio. Vol. I, No. 1, May 1914, London, p. 57.

straining forward in an endeavor to liberate itself. As soon as success attended its efforts, it buried its mandibles in the leaf-tissue and commenced feeding.

The anterior extremity of the egg is proximal to the leaf-margin. The chorion splits longitudinally along the mid-dorsal line, the aperture extending almost half the length of the egg. In emerging, the grayish-white larva, almost transparent, avails itself of its tubercles in disengaging itself from the egg-case. In that they are posteriorly directed, their function in assisting the larva to liberate itself from the egg, is at once apparent.

When the larva has succeeded in emerging, the aperture in the chorion has assumed an ellipsoidal shape. The empty egg-case remains in the slit originally made by the ovipositor of the adult, and on no occasion was the larva observed to devour it.

Larval Habits.—The first-stage larvæ (July 7) are semi-translucent, grayish-white, and measure 1.19 mm. long by 0.37 mm. broad. The alimentary canal by reason of its contents, is yellowish-green or sometimes reddish-brown, and the head is black. The larvæ feed on both the upper and lower surfaces of the leaf, embedding their mandibles through the epiderm and eating the parenchyma inside. Whether working on the upper or lower surfaces, the first-stage larvæ rarely disturb the epiderm of the surface other than that on which they are feeding. Their activities are later accentuated by the parts which are eaten, turning a brownish-black, shrivelling and dying.

The young larvæ are very sluggish and not readily disturbed when feeding. The mandibles are very firmly embedded in the leaf-tissue. Gentle exhortation with a camel-hair brush will not serve to induce them to loosen their hold. They assume various attitudes. Usually they lie horizontally on the surface of the leaf, but often the only part of their bodies in contact with the leaf, is the head and mandibles. In the latter case, the rest of the body is elevated at varying angles to the leaf-surface. Sometimes the larva may literally stand on its head with the abdomen erect and vertical. Again, it may assume a looped position where the abdomen is recurved dorsally, and its extremity comes to rest in close proximity with and anterior to the head, like an inverted U, the arms of which are almost closed.

Often they drop voluntarily from the leaves to the ground. It is supposed that many never regain their original positions

but perish either from starvation or are preyed upon by spiders and insect predators.

In nine days (July 16), the larvæ had increased in length to 5.84 mm. long, although a few were only 3.57 mm. Except for the green color of the alimentary canal, they were of a dirty grayish hue. Even in the young stages they display all the characteristic behavior and movements of the full-grown larva, which can be most aptly compared with those of "measuring worms" or "looper" caterpillars (Geometridæ).

The first larval moult occurs after a period of about 18 to 21 days, although in some cases it did not take place for 5 or 6 weeks. Growth is very slow and quite in accord with the sluggishness displayed by the animal. Previous to this first moult, the larvæ, in moving over the leaves, become invested with particles of their excreta which adhere readily to the skin as if it were coated with a sticky substance. The freshly-moulted larvæ are almost translucent white, and the two tracheal trunks with their ramifications are readily distinguishable by the aid of the binocular microscope.

The larvæ have the power, when young, of secreting a silken thread from the mouth, which is probably the product of the salivary glands. They frequently adhered by this thread to the camel-hair, water-color brush used in transferring them from one leaf to another. The power to produce this thread is but limited, and on no occasion was it observed to be of any great length. Usually, it measured not more than half-an-inch.

The second-stage larvæ gradually assume a leaf-green color as they continue to feed, obscured in some by a brownish pigment beneath the cuticle. Laterally, in the more mature first stage larvæ, on each side of the median, dorsal line, there runs an irregularly-defined, brownish-gray band somewhat interrupted intersegmentally. In the larvæ of the second stage, these bands may still persist or give place on each segment to two similarly colored lines representing a V, the arms of which, however, do not meet and fuse posteriorly. On each side, the band on any one segment is parallel with that on the others.

Towards the end of July, more accurately, on the 26th, coincident with the dying off of the food-plant, *T. grandis*, the larvæ which had now assumed a size of 8.32 to 9.00 mm. long, became quiescent and ceased to feed. Previously, in the middle of July, when the larvæ in the breeding-cages were transferred

to fresh food-plants they evinced a decided tendency to creep under the curled-up edges of withered leaves. Feeding and movement gradually ceased completely, and they remained clinging motionless to the leaves. When disturbed, they rolled up, like a watch-spring, moved about a little and then resumed their dormant attitude again. It was also observed that as the leaves withered, the larvæ dropped off and, if possible, attached themselves to the stems. In the breeding-cages, they adhered to the edges of the plant-pot. In the field, they fell to the ground among the dead leaves, and under these they passed the winter in a dormant condition. In color, they match exactly that of their environment of dead leaves, but a large number seemed to retain their original leaf-green tint. In the beginning of September, the larvæ had apparently contracted a little and now measured only 7.00 mm. long by 1.50 mm. broad. This apparent shrinking was probably associated with insufficient moisture under breeding conditions.

The over-wintering larvæ first begin to show signs of activity in March when the *Trautvetteria* sends up its fresh shoots. The growth of the larvæ then proceeds quite rapidly until the larvæ pupate in the middle of May.

In many respects, the details of the larval life-history agree with those of the species *glabrata* of the closely allied genus *Liogma*, as described in the admirable paper of Dr. Mueggenberg published in 1901. Mr. Alexander (*loc. cit.*, p. 106) quotes this author as having found the larva feeding on the moss *Hypnum squarrosum* Brch. and Schp. in the wet, grassy spots of woods in the environs of Berlin. According to Mueggenberg, the larva moults several times, probably at least eight, which Alexander says is the number determined for *Phalacrocera* by Bengtsson. As to the exact number of moults of the larva of *C. splendens*, the author is unable at prsent to make a definite statement. With tolerable certainty, it can be stated that close observation revealed only one moult as occurring before hibernation and two after, the last being the casting of the larval skin previous to pupation. In the penultimate stage, the larva measures 15.00 mm. and the full-grown larva 17.00 mm. The duration of the various larval stadia, except that of the first, cannot be stated with any degree of accuracy, but it is hoped that it will be possible to decide this, as well as the number of larval moults, later.

The behavior of the full-grown larva (Figure 1), presents much that is interesting. The larva is invariably found on the upper surface of the leaf and in the spring is actively engaged in feeding. On a fresh leaf the larva usually begins by skeletonising it, leaving the lower epiderm intact. Later, however, large holes are eaten completely through the leaf.

Reference has already been made to the extraordinary movements of the first-stage larva. These are much more accentuated in the full-grown animal. The organs used in facilitating its travel, are chiefly the mandibles and the abdominal pro-legs or *pseudopodia*,* which are merely ventral protrusions, of the body-cavity two on each of the last eight segments. They are apparently distensile, and it would appear as if they were capable of secreting some kind of fluid that assist the animals in retaining its hold on a smooth surface, especially so if the surface be inverted. On the three thoracic segments there are no definite pseudopodia, but the function of these is served by the development of a distinct, ventral fold which becomes apparent as the animal contracts. Two pairs of small tubercles or papillæ on the ventral surface of each thoracic segment, are also employed in locomotion.

In moving forward, the last segment is elevated from the leaf-surface. Simultaneously almost with this action, the middle region of the body contracts and arches so that one pair of pseudopodia after another is methodically raised from the leaf in a postero-anterior direction. The last segment comes to rest in a position about half-an-inch anterior to its original one. A series of rhythmical, muscular contractions pass wave-like along the body from segment to segment, pulling the two extremities towards each other with the result that the body assumes the shape of an inverted U involving at first only the abdominal region. The contractions pass along to the thorax and head which also become arched, whilst the pseudopodia of the last five body-segments are applied to the leaf-surface again. The inverted U is then composed of that part of the body anterior

*The author has preferred to apply the name *pseudopodia* to the unsegmented, paired tubercles of the abdominal segments because of their locomotory function as well as their acting as adhering agents. They are charged with body fluid and tracheated. The mechanism which determines their close application to a surface is apparently blood pressure, and this together with the aid of the viscid fluid which they secrete, is capable of maintaining the weight of the larva by surface-tension on an inverted glass-surface.

to the fifth last abdominal segment. All this time the mandibles of the larva have remained fixed, but when the last five segments have renewed contact with the leaf, the head is slowly raised. The anterior region of the body may be moved slowly from side to side, finally extending straight forward, eliminating the arch of the inverted U. The whole body then comes to rest on the leaf. The final result of this methodical series of movements is that the animal has now advanced in its progression just as far as the distance measured by the last body-segment in its original displacement. The whole process is marked by the extreme slowness of an orderly series of individual reflex, actions which impart to the observer the notion of an apparent calculation on the part of the organism by reason of their perfect co-ordination. The persistence of the appropriate stimuli determines the continued repetition of the whole series of ambulatory reactions.

In a quiescent condition, the thoracic region of the body has a noticeably humped appearance, apparently produced by the slight ventral retraction of the head-segment.

The full-grown larvæ are very sluggish and inactive. When disturbed, they relax their hold on the leaf-surface and readily fall to the ground. This response to a disturbing factor, together with their marked resemblance to the leaf-color, appears to be their only asset of defense against predaceous species. In all, somewhat more than one hundred adults were reared from larvæ collected in the field, and in not a single instance was one found to be parasitised.

Pupation.—Previous to pupating, the larva attaches itself firmly to the surface of the leaf or leaf-petiole by means of its anal pseudopodia. The skin splits transversely posterior to the head but is only partially sloughed off. The head, thorax and first four abdominal segments of the pupa are exposed, but the remainder of the abdomen remains enclosed in the larval skin, the terminal portion of which, attached to the leaf-surface, is collapsed and wrinkled. The head-capsule of the larva which is moulted with the rest of the exuvium, lies ventrad of the fifth abdominal segment of the pupæ. On the leaf, pupation may take place on both the upper or lower surfaces, but generally on the former. On the petiole, the pupæ generally occur at the axils.

Duration of Pupal Period.—In the breeding-cages, the period of pupation varied from six to ten days. Mueggenberg, quoted by Alexander (*loc. cit.*, p. 106) states that for *Liogma glabrata* the pupal period persists for 11 to 12 days, and it will be probably found that in individual cases the period is as long for our species under natural conditions in the field.

Emergence of Adult.—The pupal skin splits in T-shaped fashion on the dorsal region of the thorax. The adult thorax and head are the first to appear followed by the wings. After a series of efforts, punctuated by periods of quiescence, in which the prevailing movement is a straining forward of the free parts of the body, the legs are unsheathed from their closely-investing cases and the adult emerges. At first, it is of a pale-green color which gradually gives place to the yellow and black of the mature animal.

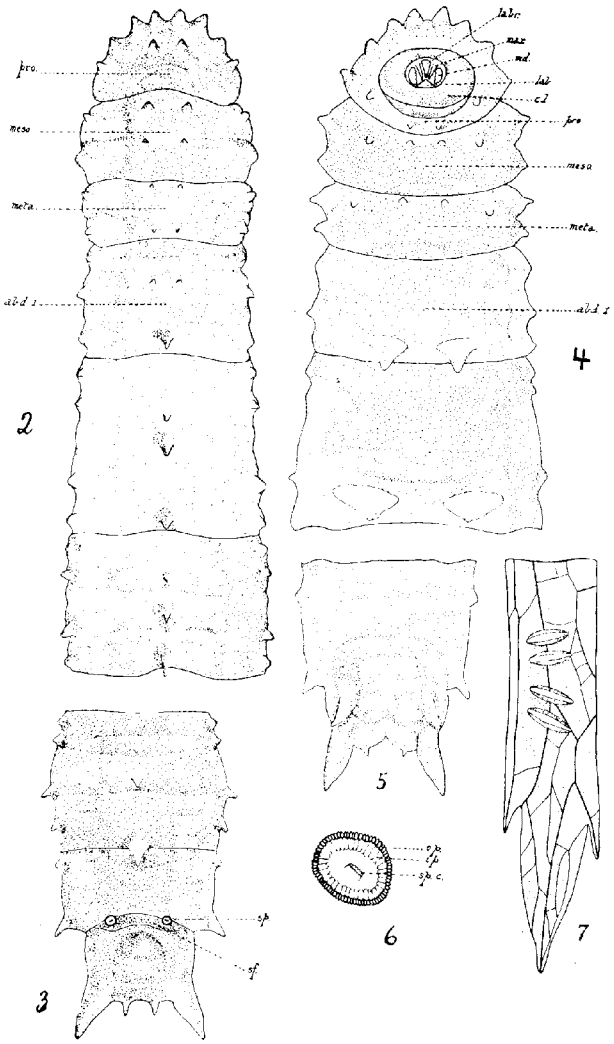
The process of emerging occupies one and a half to two hours, and after it is completed, the adult rests for a short time until the cuticle hardens and the wings expand. A tiny drop of green fluid is voided from the alimentary canal soon after the exit is made.

The pupal skin is never at any time completely uncovered and when sloughed off by the adult, still retains the adhering last larval skin. In some cases where the pupæ had been gently withdrawn from the last larval skin and placed on the floor of the breeding-cages, the adults experienced great difficulty in emerging, and a few, indeed, did not succeed in liberating themselves at all. It is evident, therefore, that the fast adherence of the last larval skin to the leaf-surface and its close investment of the pupa, serves a useful function in facilitating the successful emergence of the adult.

PROPORTION OF SEXES.

From 108 adults reared from larvæ collected in the field, 91 were females and the remaining 17 males. Thus the percentages of females and males reared were respectively 84.2% and 15.8%.

On June 1, 96 individuals were captured by sweeping the food-plant, *T. grandis*, at Westholme, when the males were found to be in the ascendant in the proportion of 60.2% to 39.8%. On this date many were taken in copulâ.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The marked discrepancy between these two sets of figures appears at first sight to be inexplicable. It is probable, however, that the figures resulting from rearing the adults from the larvæ, represent approximately the actual superiority in total numbers of the females over the males. On the date that the collection was made at Westholme, there were comparatively few adults to be seen. When one adds to this the fact that the females emerge in larger numbers before the males and that they die off soon after laying their eggs, the greater proportion of the later-emerging males towards the end of the adult season on June 1, is readily accounted for. It has already been noted that a single male may copulate with several different females.

DESCRIPTION.

Egg (Fig. 7)—When first deposited, the egg is sub-translucent, grayish-white, spindle-shaped, partly inserted beneath the slit epiderm of the leaf. The chorion is unornamented. It measures, on an average, about 0.840 mm. in length and about 0.303 mm. in breadth at the widest part in the middle.

Just before hatching, two, dull-red spots corresponding to the eyes of the young larvæ are apparent at the anterior end. The black head-capsule of the young larva is also readily distinguishable.

Full-grown Larva (Figs. 2–6).—Length, 17 mm.; maximum breadth, 2.5 mm.; maximum depth, 1.5 mm.

The live larva (Fig. 1) chlorophyll green, closely resembling in color that of the leaves of the food plant, *Trautvetteria grandis*, except for the sclerites of the head-capsule which are black, the less heavily chitinised parts brown. In bright sunlight, the lateral tubercles and margins of the body almost transparent. Dorsally, the middle region of the body darker green because of the contents of the alimentary canal within. The two, main, tracheal trunks apparent as silvery strands, running laterally and posteriorly to their termination in the spiracles of the eighth abdominal segment. Some of the tracheal branches also evident. Two irregular, sub-parallel, fuscous, brown bands on each side of the mid-dorsal line extending from the mesothorax to the spiracles of

EXPLANATION OF FIGURES.

Fig. 2. Larva, dorsal aspect, thoracic and first three abdominal segments; *pro.*, prothroax; *meso.*, mesothorax; *meta.*, metathorax; *abd. 1*, first abdominal segment. × 14.

Fig. 3. Larva, dorsal aspect, last two abdominal segments, *sp.*, spiracle. × 16.

Fig. 4. Larva, ventral aspect, head, thoracic and first two abdominal segments, *labr.*, labrum; *max.*, maxilla; *md.*, mandibles; *lab.*, labium; *c. l.*, circumoral lip. Other lettering as in Fig. 1. × 16.

Fig. 5. Larva, ventral aspect, last abdominal segment. × 20.

Fig. 6. Spiracle; *o. p.*, outer periphery; *i. p.*, inner periphery; *sp. c.*, spiracle cleft. Camera lucida drawing. × 80.

Fig. 7. Eggs deposited in the slit epiderm of leaf of *T. grandis*. The ruptured epiderm partly envelops the egg. × 7.

the ultimate abdominal segment and indicated in Figures 2 and 3, by the darker shading; often faint and indistinct in parts on the anterior segments, but generally well-defined posteriorly. Lateral margins of the body appressed. Skin delicately reticulated and tuberculated, transversely rugose both dorsally and ventrally with the wrinkles either isolated, separate and sub-parallel, or converging and confluent.

Prothorax (Figs. 2 and 4, *pro*) with a broad, circumoral lip (Fig. 4, *c. l.*) on ventral surface, penetrated in the middle by the transverse slit through which the head-capsule may be exserted. Two pairs of ventral tubercles, the members of the inner pair small and merely papillæ. Anterior, marginal tubercles three pairs, the median pair largest. One pair of lateral tubercles. One comparatively large pair of dorsal tubercles.

Mesothorax (Figs. 2 and 4, *meso*), 2 pairs of tubercles ventrally as in the prothorax, small. Two lateral pairs, of which the members of the anterior pair are more pronounced. Two pairs of median, dorsal tubercles the members of the anterior pair the larger.

Metathorax (Figs. 2 and 4, *meta*), with the ventral and lateral tubercles similar to those of the mesothorax. Two pairs of small, median, dorsal tubercles, all of equal size, the members of each pair equally separate but not so widely separate as the median dorsals of the mesothorax.

Abdominal segments, dorsal tubercles: first segment (Figs. 2 and 4, *abd 1*) with an anterior, small pair of tubercles and a larger median, posteriorly-directed, single one behind. Segment II with three, single, posteriorly-directed median tubercles, of which the first is smaller than the second and the second than the third, the first and second not so widely separate as the second and third. Segments III–VII each with three, single, median, posteriorly-directed tubercles as in Segment II, the first equidistant from the second as the second from the third; the third tubercle largest of the median dorsals in each of these segments. *Lateral tubercles:* segments II–VII each with four pairs of tubercles of which the members of the second and third are more prominent than those of the first and fourth. *Ventral tubercles:* first segment with one pair of *pseudopodia** situated posteriorly, broad at the base, bluntly conical in shape. Segments II–VII each with a posteriorly-situated pair of pseudopodia, larger than those of segment I, more widely separate and bases broader.

Eighth segment (Figs. 3 and 5) bearing the stigmal field and the caudal appendages. Posteriorly, two pairs of processes of which the members of the outer pair are directed latero-posteriorly, larger than the members of the faintly-brownish, inner pair which are situated just posterior to the anal orifice. Lateral tubercles two pairs, of which the posterior pair is the larger, posteriorly directed. Ventrally, on each side of the two rounded, anal swellings representing the pseudopodia of other segments, is a pair of large, lateral, anal processes, directed latero-posteriorly. The stigmal field (Fig. 3, *s f.*) somewhat depressed,

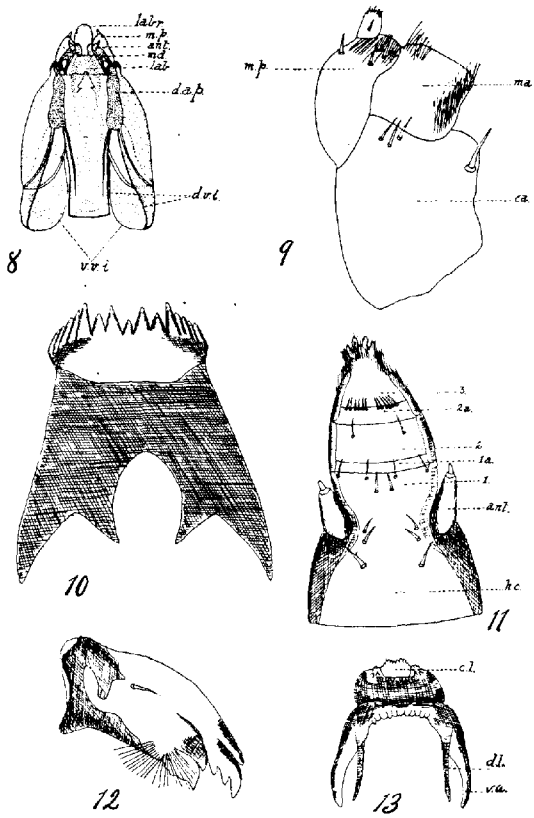
*Explanation has already been made that this term was adopted to signify the paired, ventral, locomotory tubercles of the abdominal segments.

transversely elongate, somewhat overlapped anteriorly by a cuticular fold. The oval-rounded stigma (*sp.*) consists of a transverse slit with scalloped edge, encircled on the outer periphery by two scalloped margins, the outer of which is densely chitinised. The stigmata are somewhat widely separate.

Head-capsule of Larva and Mouth-parts (Figs. 8-13). —Head retracted into the first thoracic segment, mandibles, maxillæ, labium and labrum apparent in ventral view (Fig. 8). Antennæ (Figs. 8 and 11, *ant.*) arising from head-capsule at base of labrum, 2-segmented, the first elongate, pear-shaped, much stouter than the second, thimble-shaped segment. Mandibles (Figs. 8 and 12, *md*) strongly chitinised, many-toothed ventrally, beset with a ventral tuft of hairs posterior to the odontophore extremity. They operate with a latero-vertical movement. Maxillæ very short and broad, consisting of a two-segmented palp (Fig. 9, *m. p.*) and inner lobe (*mala*); second segment of palp thimble-shaped and much smaller than the broad, splint-shaped, first segment; mala (*ma*) beset with a brush of bristles on its inner, lateral margin and a smaller one on its anterior, outer corner. Labrum (Figs. 8-11, *labr.*) tongue-shaped, terminating in four teeth anteriorly, the internal pair larger than the external pair; stoutly chitinised marginally, margin appearing as if involute ventrally, terminally and antero-laterally beset with close-investing hairs; a few, sparse, bristles distributed regularly on its surface; 3-segmented (*1, 2, 3*), with two paler intersegmental bands (*1a, 2a*). The labium (Fig. 10) deeply incised posteriorly to form two broad arms, each of which is again incised posteriorly in fish-tail fashion; more strongly chitinised posteriorly than the anterior odontophore margin which bears seven teeth on each side of the median small one, the first and third of each side being the largest. Hypopharyngeal sclerite (Fig. 13), dorsal to the labium, provided with two rows of tiny denticles; strongly chitinised; excavated anteriorly troughwise, a weakly chitinised, central lobe (*c. l.*) provided with an anterior, denticulate margin filling the excavation; posteriorly, on each side, a pair of arms, the dorsal member of each pair (*d. a.*) more slender than the ventral (*v. a.*).

Articulating with the external, posterior angle of the mandible is a pair of stoutly chitinised, elongated processes (Fig. 8, *d. a. p.*), broadening considerably posteriorly where they are deeply incised to form two slender arms of which the outer, directed postero-laterally, is apparently continuous with an equally slender process given off ventrally from the labium; the inner tapers off gradually in the dorsal wall of the capsule. Anteriorly, from each dorsal, articulating process, there arises laterally a small process which partly encircles the ocular aperture. The slender, chitinous continuations of the various sclerites serve to support and strengthen the very delicate, transparent walls of the head-capsule.

In the walls of the capsule itself, (Fig. 8) there is dorsally on each side a deep, v-shaped incision (*d. v. i.*) separated by a tongue-process, sharply truncate posteriorly and ventrally, a similar incision situated medially and ventrally (*v. v. i.*).



EXPLANATION OF FIGURES.

Fig. 8. Head-capsule of larva. *Labr.*, labrum; *m. p.*, maxillary palp; *ant.*, antenna; *md.*, mandible; *lab.*, labrum; *d. a. p.*, dorsal articulating process; *d. v. i.*, dorsal V-shaped incision; *v. v. i.*, ventral V-shaped incision. × 30.

Fig. 9. Maxilla of larva; *m. p.*, maxillary palp; *ma.*, mala; *ca.*, cardo. Camera lucida drawing. × 115.

Fig. 10. Labium of larva. Camera lucida drawing. × 160.

Fig. 11. Labrum of larva; 1, 2, 3, number of segments; 1a, 2a, intersegmental areas; *ant.*, antenna; *h. c.*, head-capsule. Camera lucida drawing. × 130.

Fig. 12. Mandible of larva. Camera lucida drawing. × 160.

Fig. 13. Hypopharyngeal sclerite of larva; *c. l.*, central lobe; *d. a.*, dorsal arm; *v. a.*, ventral arm. Camera lucida drawing. × 115.

Pupa (Fig. 14).—Length from head to tip of abdomen, ♂, 11.7 mm.; ♀, 13.3 mm. Length from head to tip of tarsi, ♂, 5.9 mm.; ♀, 6 mm. Dextro-sinistral width at the wing-pad, ♂, 2.2 mm.; ♀, 2.8 mm. Dorso-ventral depth at the wing-pad, ♂, 1.4–1.6 mm.; ♀, 2 mm. Color leaf-green, thoracic spiracles grayish-white, margins of abdominal segments sub-translucent, eyes black in mature individuals.

Bases of antennæ arising between the cephalad half of the compound eyes, slightly divergent on either side of the mid-ventral line, more so in the male than in the female. In the *male*, the antennæ rather enlarged, bending round and closely applied to the anterior margin of the compound eye as far as the point where the palpi, reflexed antero-laterally, terminate; then directed postero-medially in the line between the fore femora and tibiæ, the extremity about on a level with the lobes of the labium. In the *female*, the antennal sheaths less stout, continuing around the anterior margin of the eye latero-posteriorly, abruptly bending posteriorly a short distance from their tips to terminate above and just beyond the proximal extremity of the second tibiæ; in mature specimens, the irregular, nodose segments of the adult antennæ apparent through the transparent sheath. Eyes large. Labium elongate, triangular. Head flat and broad dorsally, sloping back to the thorax, devoid of tubercles.

Pronotal breathing horns prominent, somewhat enlarged distally, directed antero-laterally with a distinct, ventral inclination. Mesonotum faintly wrinkled, pronouncedly arched, with two tubercles one on each side of the dorso-median line at the apex of the arch, directed cephalad and laterally; slightly anterior and external to these, a smaller tubercle at the base of wing-sheath. Metanotum devoid of tubercles, slightly wrinkled. The fore femur long, terminating on a level with the middle region of the eye, fore tarsi longest, hind tarsi shortest with a corresponding relationship in the comparative length of the segments of each tarsus. In the *female*, the tip of the hind legs just anterior to the caudal margin of the third abdominal segment, extending slightly beyond those of the first and second pair which are on a level; in the *male*, the tips of all three pairs of legs in alignment just anterior to the caudal margin of the second abdominal segment, the wing-cases completely overlapping the tibia and first tarsal segment of the hind legs.

Abdomen of eight segments, dorsally with the first segment half as long as the second; segments II–VII subequal in length, devoid of tubercles except in so far as small indistinct lateral protrusions may be so considered; segments with transverse wrinkles subparallel or curved, isolated or converging and confluent; lateral margins somewhat appressed. In the *male*, the eighth or terminal segment contains the genitalia of the adult; the ninth tergite a small, well-defined plate with posterior margin slightly concave, lying superior to but only partially covering the valve of the ninth pleurite with its recurved appendages which extend beyond, both laterally and posteriorly; the pleural appendages distinctly evident, recurving dorsally on each side of median line of the valve and terminating at the ninth tergite. From beneath, valve of hypopygium divided by a small, median notch into

two rounded lobes, the notch recurving dorsally to its termination at the posterior margin of the ninth tergite. In the *female*, the eighth segment encloses the ovipositor of the adult, tapering to a blunt, divided extremity; the dorsal valve deeply notched, completely obscuring and overlapping the smaller, ventral valve of which the notch is less than half that of the upper.

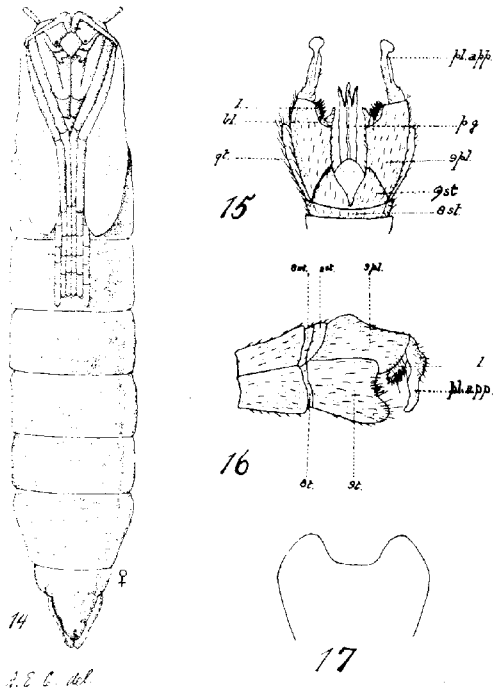


Fig. 14. Pupa (♀). × 8.
Fig. 15. Hypopygium (adult), ventral aspect; *8st.*, eighth sternite; *9st.*, ninth sternite; *9t.*, ninth tergite; *9 pl.*, ninth pleurite; *l.*, pleural lobe; *pl.*, pleural blade; *pl. app.*, pleural appendage; *p. g.*, penis guard. Camera lucida drawing. × 20.
Fig. 16. Hypopygium, lateral aspect, inverted; *8 t.*, eighth tergite; other lettering as in Fig. 2. Camera lucida drawing. × 20.
Fig. 17. Ninth tergite. Outline ofd orsal aspect. × 32.

Last larval skin invariably persistent, attached to the pupa which is only partially withdrawn; head, thorax and first four abdominal segments exposed, the remainder enclosed in the exuvium; moulted, larval head-capsule ventral to the fifth abdominal segment of pupa; posteriorly, the exuvium collapsed and wrinkled, its terminal segment adhering to the support by the anal pseudopodia.

Eggs described from numerous specimens collected from host-plant in breeding-cages at Royal Oak, Victoria, V. I., May 25, 1917, and from several found at Westholme, V. I., May 31, 1917.

Larvæ described from numerous specimens collected in rich woodland at Westholme, V. I., May 3, 1917.

Pupæ described from several specimens, ♂ and ♀ reared from larvæ at Royal Oak, Victoria, V. I., killed May 9, 1917, and from several taken at Westholme, V. I., May 15, 1917, killed on same date.

Adult. The species was first described by Doane* in 1900, who gave it the name of *Cylindrotoma splendens*. His specimens, three males, were obtained from Unalaska. In 1901, Coquillett† redescribed the species under the name of *Cylindrotoma juncta* from a male specimen collected at Virgin Bay, Prince William Sound, Alaska.

The following is Doane's description:

"*Cylindrotoma splendens*, sp. now. (Pl. VIII, Fig. 21).

Pale yellow and black; head very pale yellow almost whitish; occiput, front, rostrum and palpi brown; first and second segments of antennæ whitish, first with a brown ring, other segments brown, cylindrical, if bent back they would reach to about the middle of the first abdominal segment; thorax very pale yellow or whitish; dorsum with three opaque black stripes, the lateral ones merge anteriorly into broader brown stripes which curve in and meet the median stripe; collar with a black band; a large, black spot on the pleura between the base of the wing and the anterior coxæ, another over the anterior coxæ, and another between the first and second pair of coxæ; a smaller one just in front of the base of the halteres, and a double on the posterior border of the metanotum; scutellum with a median, brown stripe; halteres pale, slightly infuscated above and at the tips; legs brown, base of femora lighter; tarsi and tips of the tibia darker; abdomen black; male forceps large, brownish posteriorly; wings rather narrow, hyaline; stigma pale, veins brown; auxillary vein ends abruptly just before the stigma; the small, cross vein connecting the first longitudinal vein with the costa is very faint and situated a little beyond the middle of the stigma; submarginal cell either longer or shorter than the first posterior cell. (In two of my specimens it is longer in one wing and shorter in the other.) Thus the præfurca may either end in the submarginal cell or in the first posterior cell; five posterior cells, the second sessile; discal cell elongated, somewhat pointed ante-

*Doane, R. W. New North American Tipulidae. Jour. N. Y. Entom. Soc., Vol. VIII, Sept. 1900, p. 197, Pl. VIII, Fig. 21.

†Coquillett, D. W. Diptera Entomological Results. Papers from the Harriman Alaska Exp. IX. Proc. Wash. Acad. Sci., Vol. II, pp. 389–464, 1900, p. 401.

riorly; posterior cross vein a little before the middle of the discal cell; fifth vein incurved at the tip. Length, male 9 mm.; wing 9 mm."

"*Habitat:* Unalaska, three males. (Kincaid) Type No. 145. Wash. Agric. Coll. and S. of S."

Hypopygium (Figs. 15–17).—Mr. Alexander has very kindly aided in interpreting the relationships and disposition of the various sclerites which compose the hypopygium. In a letter under date of Sept. 26, 1917, he gives a lucid explanation of the whole structure.

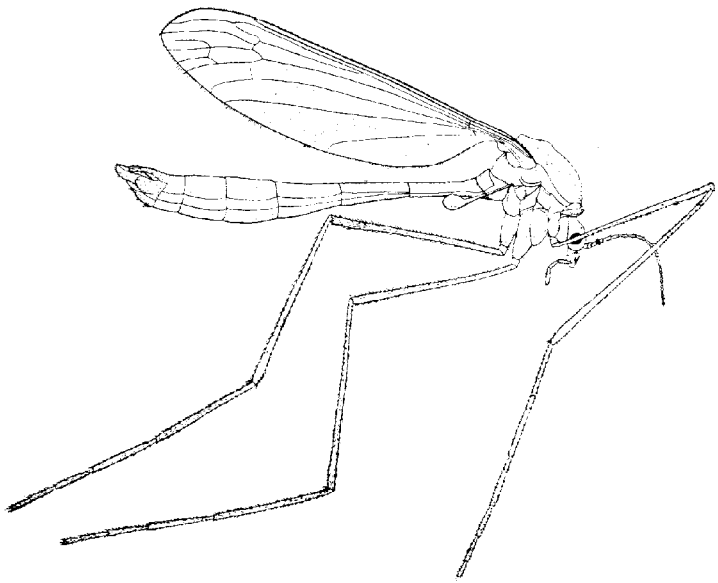


Fig. 18. Adult female. × 6.5.

"The ninth tergite (Fig. 17) large, prominent, the caudal margin with a deep, broad notch, the adjacent lobes rounded at their apices. Ninth pleurite (9 *pl*) (Figs. 15 and 16, *pl.*) prominent, the inner margin at the tip produced caudad into a small flattened blade (*bl.*), a projection of the pleurite; pleural appendage (*pl. app.*) large; fleshy lobe (*l.*), on dorsal face of pleurite densely beset with fine hairs. Ninth sternite (9 *st.*) small, deeply split on the mid-ventral line by a very acute angle. Penis guard (*p. g.*) trifid with numerous appressed teeth on the inner edge of the lateral arms."

This paper would be incomplete were I not to express my gratitude to Mr. C. P. Alexander, of Cornell University, who, as a keen student of the Tipulidæ, showed extreme interest in the progress of the work. To Mr. E. W. White and Mr. W. Downes I am also grateful, the former for first bringing the larvæ to my notice and the latter for carefully attending to the immature larvæ during my absence this summer in Saskatchewan.

SUMMARY.

C. splendens belongs to the sub-family Cylindrotomini of the Tipulidæ. The species, the life-histories of which are known, are peculiar among crane-flies in that the larvæ feed openly on Bryophytic and Spermatophytic plants.

The adults first appear about the end of May on Vancouver Island. Their distribution is apparently determined by their foodplant, *Trautvetteria grandis*, which is confined to moist, rich woodlands.

In ovipositing, the female cuts a slit in the epiderm on the under surface of the leaf by means of its saw-toothed ovipositor. The sub-translucent glistening white eggs are partially concealed. They are generally deposited in series along the margin. A few eggs may be laid on the upper surface also.

The period of incubation occupies about 2 to 3 weeks.

The recently-emerged larvæ feed on both the upper and lower surfaces of the leaves and as they develop, they eat out large holes. There would appear to be at least three moults before pupation, one previous to hibernation and two after. In their movements the larvæ show a marked resemblance to "looper" caterpillars.

About the end of July, the larvæ, now in the second-stage, cease feeding and become quiescent. In this condition they hibernate among the dead leaves. Some remain leaf-green in color, whilst others assume the dirty-brown hue of decayed leaves.

In the spring they resume feeding and grow more rapidly until they pupate in the middle of May. The pupal period lasts for 6 to 10 days. The last larval skin is only partially shed and serves to attach the pupa to the leaves and petioles.

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Agassiz, British Columbia.

NOTES ON THE GENUS BUPRESTIS LINNE IN CALIFORNIA.

By RICHARD T. GARNETT,
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This genus is represented in California by seven species an three varieties if the numbering of Henshaw's catalogue l taken as gospel. *B. fasciata* var. *langii* LeConte is, howeve nothing but the female of the western phase of *B. fasciata* Fabricius. I have before me a specimen of *langii* in which the spots are identical with those of western *fasciata*, although of an ivory color instead of yellow.

Three of our species are quite rare, two of these exceedingly so, while the rest are either common or moderately so.

The majority of the species work upon conifers, while two are known to bore in broad-leafed trees. Variety *langii* is also under suspicion of working on the latter, as it has been taken resting upon the foliage of alders and willows.

Buprestis aurulenta Linn., 14–21 mm. in length, is quite common in the Sierras and works in practically all of the pines as well as Douglas fir, western red cedar, and spruce. It is also found, but less commonly on the Coast belt, a specimen sent to me by Mr. Freeborn of the Medical Parasitology department of the University, having emerged in Berkeley. Specimens in my collection were taken at Yosemite, Donner Lake, Independence Lake, Calistoga, St. Helena, and Siskiyou County, the dates ranging from June 8 to July 30.

Buprestis laeviventris LeConte, 16–22 mm. in length, is taken commonly throughout the Sierras, especially in the north, and works on yellow, lodgepole, digger and sugar pines. Specimens in my collection were taken at Eureka, St. Helena, Mokelumne Hill, Sisson, Donner Lake, and Truckee between June 18 and September 2.

Buprestis maculiventris var. *subornata* LeConte, 17–20 mm. in length is taken in the Sierras, in Northern California particularly, where it bores in Douglas fir, and has been taken on the foliage of western yellow pine. It is moderately common in some localities. Specimens in my collection were taken at Donner Lake and in Oregon between June 10 and July 3.

Buprestis maculiventris var. *rusticorum* Kirby, 16–23 mm. in length, is found commonly in Northern California and breeds in yellow pine, Douglas, alpine, and white fir. Specimens in my collection were taken at Weed, St. Helena, Tahoe Tavern and Donner Lake, between May 25 and July 21.

Buprestis adjecta LeConte, 12–19 mm. in length, is scarce as a rule, and is found in the higher Sierras breeding in yellow and other alpine pines, probably also Jeffrey. Specimens in my collection were taken at Donner and Independence Lakes, July 3–15.

Buprestis fasciata Dejean, 10–19 mm. in length, is taken in the Sierras of northern California and is known to bore in Douglas fir, while the female, usually known as var. *langii* LeConte, has been taken by myself, Dr. E. C. Van Dyke and others resting on the foliage of alder and willow. Specimens in my collection were taken at Donner Lake, Tahoe Tavern, Muir Woods and Willits, between June 10 and July 21.

Buprestis gibbsii LeConte, 12–21 mm. in length, is taken very rarely in California. It has been taken from oak by Mr. E. Leach of Oakland and by Dr. E. C. Van Dyke. This past summer I removed adults from their pupal chambers in cottonwood at Oro Grande, San Bernardino County. Specimens in my collection were taken at Oro Grande and in Trinity County, between May 18 and July 29.

Buprestis confluens Say, 15–16 mm. in length, is taken exceedingly rarely in California, in the Great Basin and Tahoe regions. It works on poplars. Specimens in my collection were taken at Tahoe Tavern and in Colorado, July 1 22.

Buprestis connexa Horn, 14–15 mm. in length, is taken extremely rarely in Washington, Oregon and the eastern base of the Sierras in California. It works on alpine trees, having been taken from western yellow pine. One specimen in my collection taken at Donner Lake, July 7.

I have tried trapping by sawing up fresh pine wood at several localities, but without success, except at Donner Lake in 1915, between July 1 and 15. In three days I collected from a pile of yellow pine chunks 64 specimens of Buprestis, as follows: 41 *aurulenta*, var. *rusticorum* 20, *adjecta* 2, *connexa* 1. These three days were separated over several weeks, as I returned to

this pile to collect only occasionally. Several hundred Chrysobothris, mostly *C. caurina*, were also taken at this wood.

Thus California has within her borders over one-third of the species of Buprestis north of Mexico, together with two varieties of an eastern species. One of these species, *B. fasciata* Dej., is true is common to both east and west, but I think it may be said without fear of contradiction that California has a greater number of species of this genus than any other state in the Union.

)BSERVATIONS ON THE LIFE HISTORY AND HABITS OF PILOPHORUS WALSHII UHLER.

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For several summers my attention has been attracted by he large numbers of a species of black bug in a neglected apple rchard near Geneva. Specimens sent to Mr. E. P. Van Duzee ere kindly identified as *Pilophorus walshii* Uhler, of the family liridæ.

One of the most noticeable peculiarities of the insect is s superficial resemblance to a large black species of ant and) the nymphs of a Jassid, *Idiocerus provancheri* Van Duzee, both f which are commonly found on the same trees. The color f the nymphs and adults is a dark reddish brown, almost black. 'he nymphs have a white transverse band near the base of the bdomen; and in the fourth and fifth instars there is a similar ne along the posterior edge of the pronotum. The adults ave a white transverse band across the middle of the wings, n incomplete white band at the edge of the wings one-fourth 'ay from the base, and a white spot on each side of the :utellum.

During the summer of 1917 the first specimens were found n July 5 and the oldest of these were in the third instar. By ıe middle of July all stages of the insect were present, but ymphs of the third and fourth instars were the least plentiful. 'his circumstance seemed to indicate the existence of two over- ıpping generations, but a comparison with the life history f related insects makes it appear more probable that this ɔndition was the result of a prolonged hatching period. Early ı August adults became more numerous, while there was a ɔrresponding decrease in the earlier nymphal stages. From ıen on the numbers of the insects began to decline so that n September 4 only a few adults could be found, and by Sept. 5 they were absent from the trees entirely.

EGG.

Early in the summer young nymphs were observed crawling about on some strips of bark which had been cut from small apple branches and kept in the laboratory for a few days. It seems probable that they hatched from eggs contained in the bark, but none could be found, even after a diligent search on branches of various sizes.

Eggs were dissected from mature females for description and drawing. They are 1.2 mm. long by .20 mm. wide and slightly curved. At the micropyle end there are two small projections with a roughened surface. The color is white.

FEEDING HABITS.

A curious habit of the insects in concealing themselves among leaves curled by aphids led to observations on their feeding habits. It was found that aphids constitute one of their chief sources of food. Adults and nymphs of all stages jab their beaks into the aphids and suck out part of the body fluids, often withdrawing the beak several times and inserting it again in other parts of the body. When attacked the aphids secrete droplets of fluid from the cornicles and if these touch the beak of *Pilophorus* the latter will withdraw and remove the substance with the fore tarsi before proceeding further with the meal. The mutilated aphids generally die as the result of their injuries.

The bugs were also seen probing with the proboscis among the cast skins of an aphid colony as if lapping up the refuse honeydew dropped by the aphids. They occasionally vary the diet by sucking from a leaf or stem.

Several nymphs and adults were confined in a gauze bag on a fruit spur free from aphids, and although they lived over a week no injury could be detected on the leaves or the apples, either at that time or later.

In the neglected orchard, which is infested with San Jose scale, the bugs were seen running about over the large branches and this suggested the possibility that they might feed on scale insects also. They can see a moving object so far it is rather difficult to get close enough to observe their feeding

habits under natural conditions. However, one was noted with its beak inserted into a large scale, which it punctured in three other places before moving away. Another nymph, confined in a tube with a scale-infested twig, was observed directing its beak into the scales as if feeding on them.

Without further observation I cannot say whether the bugs commonly feed on scales or whether they were not merely sucking plant juices from the bark beneath the scales.

VALUE AS AN APHID DESTROYER.

In order to test the value of the species as an aphid destroyer an experiment was performed, using two small shoots of Spiraea infested by these insects. Fifty aphids were allowed to remain on each shoot and care was taken to have them free from predaceous insects. Three nymphs of *Pilophorus* were placed on one shoot and none on the other, and both were covered with bell-jars. Two days later, six aphids were found alive on the first shoot, but ninety-one were present on the control, many of them being small newly-born individuals.

The experiment was repeated using the same number of aphids, and with two adults of *Pilophorus* in one bell-jar. After twenty-four hours one of these had been on the shoot for some time, but the other was still crawling about the bottom of the jar. This shoot contained forty-one aphids, while the control had sixty-five. Both adults were placed on the shoot and the experiment was allowed to run another day, when the first shoot had twenty-three aphids and the control had eighty.

These experiments show that this species, if present in sufficient numbers, might be an important factor in holding in check the natural rapid increase of aphids.

IN RELATION TO ANTS.

The aphid-infested apple leaves are usually attended by ants, among which a large black species is common. Both nymphs and adults of *Pilophorus* are very rapid runners and carefully avoid meeting the ants. The bugs can see a large moving object, such as the hand, at a distance of one foot or more, and can detect the ants when they are several inches away. They are thus able to keep on the opposite side of a branch or

twig so that the ants pass by them. Ants appear to be unable to detect the presence of the bugs at a greater distance than one centimeter. If one happens to get this close it immediately attacks the bug, but it is doubtful if it ever succeeds in catching one.

In consideration of the poor visual powers of the ants and the helplessness of the aphids, it is hard to imagine how the striking resemblance of *Pilophorus* to the ants, with which they are often associated, can be of any value to the species either for protection or aggression. The only logical conclusion seems to be that the resemblance is purely accidental.

ALGUNOS CASOS TERATOLOGICOS OBSERVADOS EN LOS ARTROPODOS.

PROF. FRANCISCO CAMPOS R.*

1. *Caso de tarso hexámero en el Tetracha suturalis* Horn. (Coleóptero de la familia Cicindelidæ).

Es esta una espécimen cuyas extremidades son normales á excepción del tarso mesotorácico izquierdo el cual en su tercera articulación parece haber recibido fractura y soldado después. Presenta pues un tarso mesotorácico de 6 artejos lo que hace que la extremidad mesotorácica izquierda sea sensiblemente mas larga que su correspondiente metameral.

Procedencia de esta forma: El Morro.

2. *Caso de anomalia elitral en el Mallodon molarium* Bat. (Coleóptero de la familia Prionidæ.)

Consiste este caso teratológico en una hipertrofia del élitro derecho y desvìo de la línea de sutura media. Los élitros son normales en su base, y ambas piezas se tocan hasta los dos tercios de su longitud. A partir de este punto el borde interno del élitro derecho se separa de la línea de sutura dejando al descubierto parte de las alas membranosas y la margen externa del mismo élitro se expande notablemente no coincidiendo en su terminación con el extremo del élitro izquierdo el cual conserva en todo perfecta regularidad.

Hab.: Duran.

3. *Caso de bifurcacion tibio-femoral en un Calopteron sp.* (Coleóptero de la familia Lycidæ.)

Representa esta muestra aberrante un tipo heptápodo. Las patas están normalmente desarrolladas á excepción de la metatorácica izquierda la cual en la región media del femur se bifurca constituyendo desde este punto 2 piezas que se articulan después con 2 tibias perfectamente independientes con sus respectivos tarsos. El insecto en referencia ofrece pues, 7 tibias y casi puede decirse 7 fémures, puesto que la bifurcación comprende también la mayor longitud femoral.

Hab.: Chimbo.

* El suscrito catedrático de Ciencias Naturales del Colegio Nacional Vicente Rocafuerte de Guayaquil (Ecuador) y miembro de la Entomolog. Soc. of America, presenta por intermedio del Prof. J. M. Aldrich—a esa Honorable Corporación, las signientes observaciones recogidas durante su práctica de Entomologista.

4. *Caso de atrofia tibio-femoral en el Alurnus 4-maculatus* (Coleóptero de la fam. Hispidæ.)

Trátase de un ejemplar ♂ cuya extremidad mesotorácica derecha ofrece notable anormalidad. El trocanter mesotorácico es normal; femur notablemente reducido á una quinta parte de la longitud natural, tibia fuertemente curva hacia adentro, á modo de *C* y muy corta (un tercio del tamaño natural); tarso normal. El ejemplar observado por el dorso apenas deja ver el tarso de la extremidad aberrante, quedando ocultas las demás regiones de dicha extremidad, á causa de su reducido tamaño.

Hab.: Baños.

5. *Caso de aberración bicaudata en el Centrurus margaritatus* (Gerv.)—(Arácnido de la familia Scorpionidæ.)

Constituye un caso teratológico interesantísimo. Un alacrán con 2 colas completamenta distintas, bien desarrolladas, fenómeno considerado por varios autores como fabuloso. El ejemplar aludido presenta 2 postabdómenes (colas) independientes é ignalmente desarrollados, unidos al preabdomen y provistos de sus correspondientes aguijones. Se observa que, cada postabdomen aunque bien desarrollado ofrece sus metámeros algo menos fuertes que en los de un ejemplar normal.

Hab.: Duran.

Localización poco frecuente del Phthirius inguinalis.

El suscrito constata un caso de alojamiento rebelde del parásito arriba indicado, en la base de las pestañas de ambos ojos, en un niño de 5 años, y temporalmente su presencia en el cabello—(Va 1 tubo con alcohol y varios ejemplares).

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

PITTSBURGH MEETING.

The Twelfth Annual Meeting of the Entomological Society of America was called to order by First Vice President, Dr. E. M. Walker, in the Lecture Room of the Carnegie Museum, Pittsburgh, at 2.30 P. M., on December 28, 1917. On account of ill health, President Lawrence Bruner was not present. There was an attendance of sixty-five members at the opening session.

The Chair appointed the following committees:

Nominations—FRANK E. LUTZ, R. C. OSBURN, J. G. SANDERS.

Resolutions—A. G. RUGGLES, V. A. E. DAECKE, VERNON KELLOGG.

Auditing—J. L. KING, SEYMOUR HADWEN.

The following papers were read:

Studies on the Dryinid Parasites of Leaf-hoppers.....F. A. FENTON
Climatic and Seasonal Variation in Cerodonta.....J. M. ALDRICH
Observations on the Life History and Habits of Pilophorus walshii Uhler.....B. B. FULTON
An Interesting Habit of a Wax Moth Parasite.....S. A. GRAHAM
(Presented by A. G. Ruggles).
The Genitalia of Gryllotalpa and Related Forms.....E. M. WALKER

At 5 o'clock the meeting adjourned until the next morning.

December 29, 10 A. M. The meeting was called to order by First Vice President, E. M. Walker. This being the annual business session, the Executive Committee presented the Reports of the Secretary, Treasurer, the Managing Editor of the ANNALS, and of the Treasurer of the Thomas Say Foundation, as follows:

REPORT OF THE SECRETARY.

The following members have resigned since the last report:

G. A. Akerlind
N. E. Crosby
R. Etheridge
J. L. Hypes
R. J. Kewley
J. H. Paine
Mrs. A. W. Smith
A. R. Cahn
C. B. Davenport
J. B. Garrett
W. D. Kearfott
W. J. Kostir
H. A. Preston

Total—13.

The following have died: E. J. Goeldi, J. M. Lawford. Total—2.

Dropped for non-payment of dues, 28.

All losses, 43.

Elected to membership, November 1, 1917:

Ellsworth Bethel
L. L. Buchanan
F. S. Carr
B. R. Coad
Philip Dowell
A. J. Flebut
J. W. Green
L. G. Gwynn
R. H. Howe
P. B. Lawson
A. L. Lovett
J. W. McCulloch
A. J. Mutchler
E. D. Quirsfeld
F. S. Stickney
W. R. Walton
Wm. Wild
Hachiro Yuasa
Henry L. Bowers
E. E. Calder
W. B. Cartwright
H. G. M. Crawford
H. S. Fackler
R. T. Garnett
Fordyce Grinnell, Jr.
Ralph Hopping
Chas. R. Jones
A. W. Lindsey
Georges Maheux
F. J. A. Morris
Howard Notman
D. A. Ricker
M. C. Van Duzee
Ralph Whittle
C. W. Woodworth

Total—35.

Elected to membership December 28, 1917:

E. A. Chapin
Victor Duran
H. M. Fort
S. A. Graham
M. J. Elrod
Bernard Krautwurm
J. M. Langston
R. M. May
Edgar Nelson
Franklin Sherman
L. A. Stearns
F. W. Urich
Chas. A. Weigel
Howard E. Woodworth
Robt. Dickson
P. W. Fattig
Chas. W. Frost
Geo. Hofer
Henry G. Klages
M. C. Lane
Fred Marloff
C. E. Mickel
J. A. Reis
C. F. Stahl
R. C. Treherne
A. O. Weese
S. Howard Williams
V. J. Zahrobsky

Total—28.

All additions, 63. Net gain, 20 members.

Frederick Knab, a charter member, was elected a Fellow by the Executive Committee on May 1.

The membership on December 24, 1917, was in the following classes (in which Fellows are not separated from Members):

Honorary Fellows	7
Life Members	4
Paid for 1918	193
Paid for 1917	189
Paid for 1916	66
Paid for 1915	31
Paid-up, foreign	20
Other foreign	34
Total except new	543
New in 1917	63
Total membership	606

The Secretary has endeavored to make a list of members in war service, but it is very incomplete (hence not printed; the Secretary did not bring up the matter of remitting dues of members in service below commissioned rank, as intended, on account of his inability to get anything like a list of such members at present).

Respectfully submitted,

J. M. ALDRICH, *Secretary.*

REPORT OF THE TREASURER.

RECEIPTS.

Balance December 14, 1916, (Annals, March, 1917, p. 100)	$ 38.82
Dues from members	1,282.15
From Managing Editor of Annals	280.14
Interest on permanent funds, January and July	10.58
Interest on current balance	11.03
Exchange	.15
Total	$1,622.87

DISBURSEMENTS.

Printing five numbers of Annals	$1,161.22
Transferred to Managing Editor, subscriptions	3.15
Refund to F. A. Fenton	2.00
Printing and stationery, Secretary's office	39.48
Stamps, stamped envelopes, postal cards	51.60
Clerical assistance, Secretary's office	47.00
Interest on permanent funds, re-deposited	10.58
Minor office expenses	3.85
Balance on hand, December 20, 1917	303.99
Total	$1,622.87

The Society owes for the last number of ANNALS, and has a sufficiently large balance to pay this bill on presentation. The total income of the Society ($1,622.87, minus the second and third items under disbursements, plus Managing Editor's receipts except the transferred item of $280.14) was $1,787.88, the largest in its history.

CONDITION OF PERMANENT FUNDS.

Four Life Memberships	$200.00
Samuel Hubbard Scudder Fund	50.00
Accumulated interest to last report	12.48
Total last report	$262.48
Interest added January and July, 1917	10.58
Present total	$273.06

Respectfully submitted,

J. M. ALDRICH, *Treasurer.*

REPORT OF THE MANAGING EDITOR.

The Managing Editor is pleased to report a satisfactory year considering the unsettled conditions that have had to be met. The receipts of this office have been $450.30 and the expenditures $170.16, leaving a balance of $280.14, turned over to the Treasurer.

A condensed summary of the items follows:

RECEIPTS.

Subscription account	$243.65
Sale of Back Numbers	114.50
Reprints and authors contributions	92.15
	$450.30

DISBURSEMENTS.

Stamps, Express and Post Office Charges	$ 27.06
Stenographic Help, Office Supplies and Labor	34.83
Engraving	108.27
Balance to Treasurer	280.14
	$450.30

The volume issued contains 418 pages, only slightly less than for the preceding year and the expense has been kept approximately the same by the use of a lighter weight paper which, however, is of excellent quality. A number of authors have very kindly contributed toward the preparation of plates which has enabled us to use a larger number of illustrations than would otherwise have been possible.

A number of back volumes have been sold and I am pleased to acknowledge the assistance of various members who have helped in placing such volumes and trust this favor will be continued for the coming year.

We have a number of available papers on hand, in fact the supply has surpassed the available space, but it seems to me that we should for the coming year keep safely within the estimated income of the Society for publication, selecting with care those papers which are most desirable for immediate publication and trusting that authors will appreciate the necessity for delay in some instances.

Respectfully submitted,

HERBERT OSBORN,
Managing Editor.

THE REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION.

As no report was filed by the former treasurer, the entire financial history of the Say Foundation from the beginning is here reported. This does not include the expenditure of the grant from the Entomological Society of America, which has been reported by the Secretary and audited previous to this time.

RECEIPTS.

1 subscriber @ $25	$ 25.00	
34 subscribers @ $10	340.00	
91 orders @ $3	282.00	
Postage received	1.08	
	$648.08	
Less discounts allowed	5.30	
Total net receipts		$642.78

EXPENDITURES.

Printing 1000 copies of Sarcophaga & Allies	$406.80	
Binding 200 copies	49.20	
Postage	15.04	
Advertising	15.03	
Miscellaneous expenses	4.19	
Total expenditures	$490.26	
Cash on hand to balance	152.52	
Total		$642.78

OBLIGATION.

1 subscriber @ $25 (balance)	$ 22.00	
34 subscribers @ $10 (balance $7 each)	238.00	
Total obligation	$260.00	
Less cash on hand	152.52	
Net obligation		$107.48

This obligation will require the sale of 38 more volumes to liquidate.

Distribution to December 19, 1917.

It will be observed that there are more than enough copies of bound volumes on hand to cover the deficit if sold, so that no further expenditure along that line need be incurred.

Respectfully submitted,

E. D. BALL, *Treasurer.*

REPORT OF THE THOMAS SAY FOUNDATION.

The activities of the Say Foundation have been confined to the distribution of Volume I, "Sarcophaga and Allies."

Owing to the financial condition, as shown by the Treasurer's Report, and the unsettled condition incident to the war, no further publication has been considered.

In addition to the seventeen names, listed on page 111 of the ANNALS for March, 1916, the following persons have subscribed to the Say Foundation:

18. P. J. Parrott
19. R. C. William, Jr.
20. Thos. L. Casey ($25)
21. William Wheeler
22. R. W. Harned
23. American Ent. Soc.
24. A. C. Burrill
25. R. W. Doane
26. Jas. K. Thibault
27. } Names
28. } not
29. } reported
30. J. H. Comstock
31. E. D. Ball
32. Economic Entomologist, Pa.
33. J. J. DeGryse
34. J. F. Illingworth
35. Frederic V. Green

J. M. ALDRICH,
E. D. BALL.

On the Editorial Board of the ANNALS, the Committee has appointed W. S. Marshall, Vernon Kellogg and F. E. Lutz, succeeding P. P. Calvert, J. W. Folsom, and H. C. Fall. On the Thomas Say Foundation, the Committee has reappointed J. M. Aldrich, Editor; E. D. Ball, Treasurer, and E. B. Williamson; and has appointed P. P. Calvert to succeed Morgan Hebard, in war service.

On motion, the report of the Executive Committee was accepted.

The Committee on Nomenclature made the following report:

REPORT OF THE COMMITTEE ON NOMENCLATURE.

Rules of nomenclature have been formulated to facilitate procedure and to prevent, so far as possible, doubt as to the validity of scientific names. There is certainly need of assistance along these lines and if rules are drafted in a conservative spirit and generally followed, we believe that much benefit and little annoyance will result.

The following is respectfully submitted with a recommendation for favorable action:

(1) Generic names should not be considered homonyms unless spelled alike.

(2) Specific names should not be considered homonyms unless originally placed in the same genus, or the earlier name originally referred to the genus to which the later belongs, or the earlier name to be referred to the same genus as the later as a valid species.

Examples: A. b. 1820. A. b. 1840. The latter is a homonym.

A. b. 1820 (now called B. b.). C. b. 1840 (now referred to genus A. as A. b.). The latter is a homonym.

A. b. 1820, now called B. b., a valid species. B. b. 1840. The latter is a homonym.

A. b. 1820 was referred in 1830 to B. as B. b., but is a species of C. B. b. 1840 (the latter is a valid species of B.). Not a homonym.

A. b. 1820 is a species of B., but a synonym of B. c. C. b. 1840 is a valid species of B. (B. b.). The latter is not a homonym.

This interpretation of the rule may be questioned and is here presented for the purpose of stimulating discussion.

(3) A type locality should be cited whenever possible. It can do no harm and may be of material service in establishing the identity of a species.

The advisability of using a single type in taxonomic work was referred to this Committee at the last meeting with instructions to report.

(4) The designation of a holotype is recommended whenever practical and it is advised that the specimen be selected with considerable care in an effort to secure a form typical of the species..

The holotype should, when possible, be accompanied by a series of specimens showing the range of variation and the entire lot might well be designated as a type series.

There are small delicate insects where the designation of a holotype is not customary, such as balsam preparations of Aphididæ, Coccidæ and Itonididæ, especially where it is necessary to examine several specimens in order to ascertain structural details. These are certainly type series and should be so designated on the labels, but it is desirable to mark one specimen (as by a ring on the glass) as a type.

Respectfully submitted,

E. P. FELT,
T. D. A. COCKERELL,
Committee.

The Committee on Entomology in the National Museum made a report, giving a brief summary of progress and suggesting the continuation of the committee.

On motion of Herbert Osborn, the only member of the committee present, the report was referred back to the committee for further consideration.

The Committee on Resolutions made the following report:

The Entomological Society of America greatly appreciate the courtesies shown to us by the local Committee of Arrangements, and particularly by our friend, Dr. W. J. Holland, Director of the Carnegie Museum.

We also appreciate and commend the efforts made to enlarge our membership, resulting in sixty-three additions this year; we should continue this effort, and in these times of stress and hardship, when all our energies are bent upon winning the war, we should look forward more than ever to these annual meetings as times when we get the inspiration to go ahead with renewed zeal, knowing that we are building the foundations of a structure that makes for conservation.

A. G. RUGGLES,
V. A. E. DAECKE,
VERNON KELLOGG.

On motion the report was adopted.

REPORT OF THE AUDITING COMMITTEE.

We, the undersigned, have examined the books of the Entomological Society of America, and find that the accounts are correct as presented by the Secretary-Treasurer, the Managing Editor and the Treasurer of the Thomas Say Foundation.

SEYMOUR HADWEN,
J. L. KING,
Auditing Committee.

On motion the report was accepted.

The nominating committee made the following report:

Your Committee respectfully submits the following nominations for officers in 1918:

President—Nathan Banks.
First Vice-President—T. D. A. Cockerell.
Second Vice-President—E. P. Van Duzee.
Secretary-Treasurer—J. M. Aldrich.
Executive Committee—C. W. Johnson, Wm. Barnes, E. M. Walker, W. A. Riley, Henry Skinner.

Respectfully submitted,

(Signed) FRANK E. LUTZ,
RAYMOND C. OSBURN,
Nominating Committee.

On motion, the Secretary was instructed to cast the ballot of the Society for the persons named to fill the various offices. He reported this to be done, and they were duly declared elected.

The members of the retiring Executive Committee asked that the president be authorized to appoint two members for the day to fill the places of absentees, in order that some Fellows might be elected; the President, having been so authorized, appointed Vernon Kellogg and Jas. S. Hine.

No further business appearing, the reading of papers was resumed, as follows:

Notes on the Early Stages and Habits of Botflies (Gastrophilus), SEYMOUR HADWEN and E. A. CAMERON

Notes on the Life History and Habits of the Ox Warble, Hypoderma lineatum.....F. C. BISHOPP and E. W. LAAKE

Session adjourned until 2 P. M.

2 P. M.—On the call to order by Vice President Walker, the Secretary announced for the Executive Committee the election of the following Fellows:

A. F. Burgess	Wm. T. Davis	Frank E. Lutz
Lawson Caesar	John J. Davis	W. S. Marshall
R. V. Chamberlin	Arthur Gibson	Frederick Muir
Guy C. Crampton	Morgan Hebard	Raymond C. Osburn
Geo. A. Dean	C. W. Leng	E. C. Van Dyke

The Secretary called attention to two specimens which were passed around, one being Oroperipains, from Panama, sent by James Zetek; the other an adult Cuterebra, reared from a house mouse in British Columbia by Dr. Hadwen.

The reading of papers was then continued, as follows:

Annotated List of Lachnosterna Enemies.....J. J. Davis
A Contribution to a Knowledge of the Life History of the Leaf-eating Crane-fly, Cylindrotoma splendens.....A. E. Cameron
Reminiscences of My Early Work Upon the Diptera...S. W. Williston
Notes on the Genus Chlorotettix.....D. M. DeLong
The Alydinæ of the United States.....S. B. Fracker
My Recent Collecting Trip to Alaska.....J. S. Hine

At 5:30 P. M. the afternoon session adjourned.

8:00 P. M.—The Society was called to order by Vice President Walker, who introduced Professor Vernon Kellogg. Professor Kellogg gave the Annual Address, upon the subject "The Entomologist and the War."

At the conclusion of the address, the Chair called upon several present to discuss its subject matter; Dr. Howard and Dr. Holland expressed warm approval, which was evidently shared by all.

The program of the Annual Meeting having been completed, the Society adjourned *sine die*.

J. M. Aldrich,
Secretary-Treasurer.

MEMBERS OF THE SOCIETY.

Date of election at left. In the list of Honorary Fellows, the parenthesis at end of address contains date of election as member, followed by date of election as fellow. Similarly, the parenthesis after address in list of Fellows contains date of election as member. Ch. signifies charter member, Dec. 28, 1906.

HONORARY FELLOWS.

1914. BETHUNE, CHARLES JAMES STEWART, Ontario Agricultural College, Guelph, Ontario, Canada. (Ch., 1906).
1914. COMSTOCK, JOHN HENRY, Cornell University, Ithaca, N. Y. (Ch., 1906).
1907. CRESSON, EZRA TOWNSEND, Hedgleih, Swarthmore, Pa. (Ch., 1907).
1914. FERNALD, CHARLES HENRY, Massachusetts Agricultural College, Amherst, Mass. (Ch., 1907).
1915. FORBES, STEPHEN ALFRED, University of Illinois, Urbana, Ill. (Ch., 1907).
1914. SCHWARZ, EUGENE AMANDUS, U. S. National Museum, Washington, D. C. (Ch., 1907).
1915. WILLISTON, SAMUEL WENDELL, Walker Museum, University of Chicago, Chicago, Ill. (1907, 1908).

FELLOWS.

1907. ALDRICH, J. M., 316 S. Grant St., Lafayette, Ind. (Ch.).
1908. BALL, E. D., State Entomologist, Madison, Wis. (Ch.)
1914. BANKS, NATHAN, Museum Comp. Zool., Cambridge, Mass. (1908).
1913. BARNES, DR. WM., 152 East Prairie St., Decatur, Ill. (Ch).
1907. BEUTENMULLER, WM., 879 Whitlock Ave., Bronx, New York City. (Ch.).
1914. BRADLEY, J. CHESTER, Cornell University, Ithaca, N. Y. (Ch.).
1914. BRITTON, W. E., Experiment Station, New Haven, Conn. (Ch.).
1914. BRUES, C. T., Bussey Institution, Forest Hills, Boston, Mass. (Ch.).
1907. BRUNER, LAWRENCE, Lincoln, Nebr. (Ch.).
1917. BURGESS, A. F., Melrose Highlands, Mass. (Ch.).
1917. CAESAR, LAWSON, Ontario Agr. College, Guelph, Ontario, Canada. (1912).
1907. CALVERT, P. P., Zoology Dept., Univ. of Pennsylvania, Philadelphia, Pa. (Ch.).
1917. CHAMBERLIN, R. V., Museum Comp. Zool., Cambridge, Mass. (Ch.).
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